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Guide for thyroid monitoring in the event of release of radioactive iodine in a nuclear emergency

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SSM perspective

Abstract

This report aims to serve as a guide in the execution of a thyroid monitoring program for laboratories with responsibility to respond with measurement capacity to a nuclear emergency.

Background

The dose contribution to the committed effective dose of ^{131}I accumulated in thyroids can be considerable as has been repeatedly shown in nuclear accidents. This makes thyroid monitoring, together with the short half-life of ^{131}I (8 days), relatively urgent in the intermediate phase of response to a nuclear emergency.

Objectives of the project

Enhance preparedness regarding in vivo thyroid monitoring

Results

For different times after intake, measured values in net count rate or dose rate are given for example instruments at the levels of the committed effective dose corresponding to a "no thyroid exposure" (< 1 mSv), the lower (20 mSv) and upper (200 mSv) action levels.

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Content

Abstract

This report aims to serve as a guide in the execution of a thyroid monitoring program during the intermediate phase of response to a nuclear emergency. Calibration factors for some instruments verified in the framework of the Nordic project THYROID (Nyander P. 2014) are listed here as an example. For different times after the intake, we present in this guide the measured values in net count rate or dose rate for example instruments at the levels of the committed effective dose corresponding to a "no thyroid exposure" (< 1 mSv), the lower (20 mSv) and upper (200 mSv) action levels.

1. Thyroid monitoring in a nuclear emergency

The response to a nuclear emergency is based on plans where predetermined operational intervention levels have been set up. According to the Nordic guidelines on the protective measures in early and intermediate phases of response, thyroid monitoring is not usually needed as ground for decisions in the early phase (NEP, 2014).

The Nordic countries have agreed upon the automatic implementation of iodine prophylaxis with of iodine pills (KI) in the early phase, for residents nearby the nuclear facility and in the areas where predictions on thyroid doses exceed 50 mGy for adults and 10 mGy for children less than 18 years of age. The dose contribution from iodine -131 (^{131}I) accumulated in thyroids to the committed effective dose can be considerable. This together with the short half-life of ^{131}I (8 days) makes thyroid monitoring a relatively urgent matter in the intermediate phase of response.

A thyroid monitoring program aims to identify the individuals, who may have inhaled or ingested ^{131}I in an amount that give rise to thyroid equivalent and effective doses exceeding the projected dose specified by the authority. The projected dose is the effective dose (often model-predicted) that would be expected to be incurred as consequence of the nuclear emergency (NEP 2014).

The projected dose is set as criterion for the decision of starting a thyroid monitoring program. The corresponding operational intervention levels are, for adults, dose rates over 100 µSv/h and/or iodine air concentration over 10 000 Bq/m^3 for two days; for children, 10 µSv/h and/or iodine air concentration over 1 000 Bq/m^3 for two days (NEP 2014).

The results of the monitoring program are useful for the assessment of thyroid doses to the different age-groups of the population that could have been exposed. These results will also serve for verifying the early phase predictions of thyroid doses based on the simulation of the transport of the radioactive plume.

General decisions concerning the allocation of responsibilities for the provision of information to the public and specifically to the persons that should be monitored, the activation of monitoring response plans, as well as the handling and storage of the monitoring data are managed by national authorities and are not in the scope of this report.

1.1. Action levels coupled to thyroid monitoring

Two levels in terms of committed effective dose are recommended (Rojas-Palma 2009): an upper action level at 200 mSv and a lower action level at 20 mSv. That is, AL_U = 200 mSv and AL_L = 20 mSv. A level called "no thyroid exposure" is usually set to a committed effective dose of 1 mSv. This "no exposure" level serves the purpose of sorting out the individuals for whom no significant exposure can be confirmed.

The actions corresponding to the different levels can be summarized as follows:
Action level 1, for measurements over the "no-exposure level but under 20 mSv:

- Provision of information
- Consider giving priority to children in long term monitoring program

Action level 2, for measurements over 20 mSv and under 200 mSv:

- Provision of information
- Consider additional thyroid and whole body monitoring (give priority to children)
- Include in long term monitoring program

Action level 3, for measurements over 200 mSv:

- Provision of information
- Referral for medical assessment
- Additional thyroid and whole body monitoring (give priority to children)
- Include in long term monitoring program

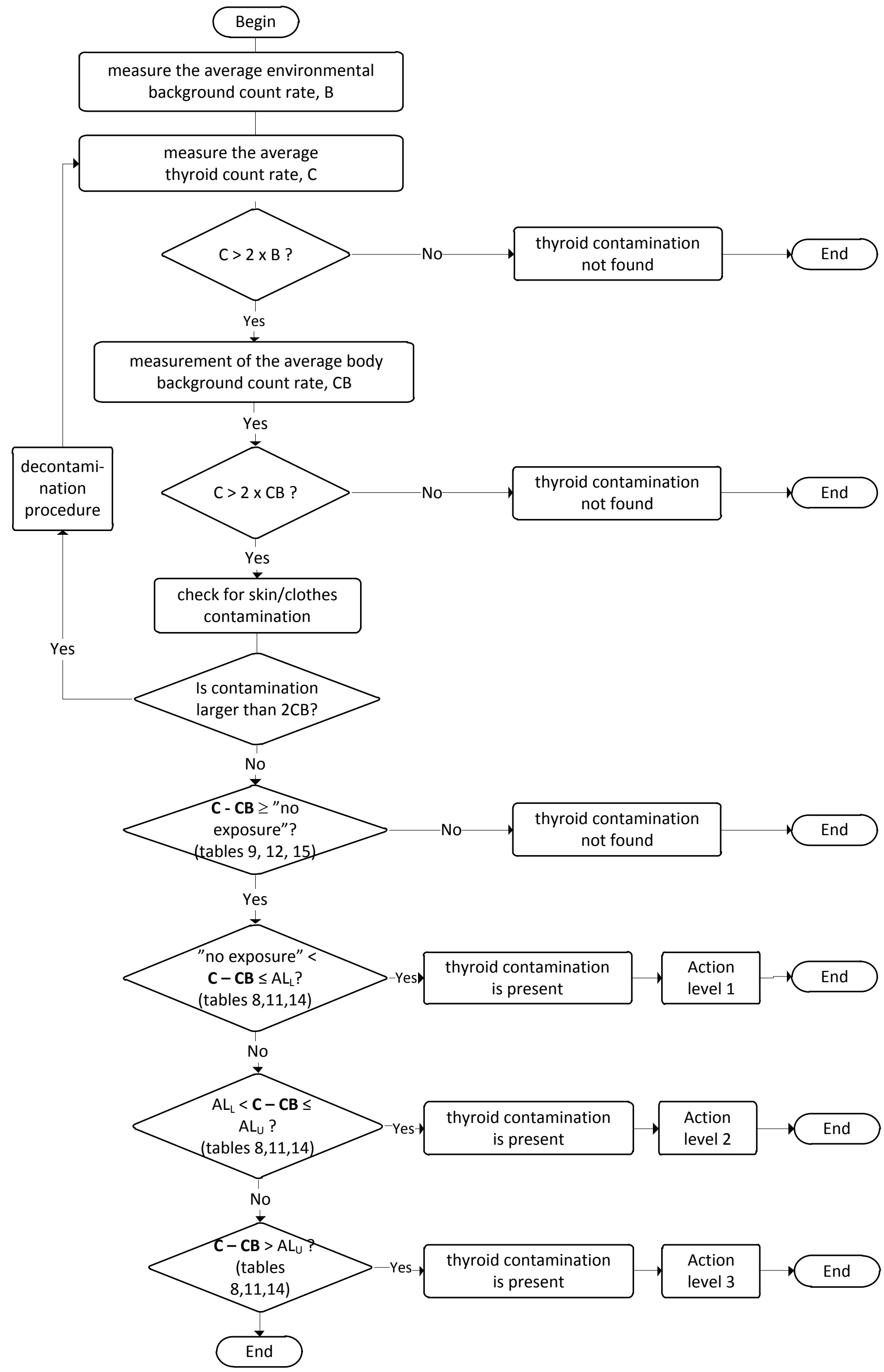
1.2. Monitoring flow chart

The flow diagram below can support laboratories in the execution of the thyroid monitoring program.

In the diagram, the average environmental count rate, B, is the average reading in the location selected for the reception of possible contaminated persons. The average thyroid count rate, C, is the reading of the instrument placed close to the skin of the neck of the subject, with the subject standing or sitting alone in the monitoring room. The average body count rate, CB, is the reading for the instrument placed close to the skin of one of the subjects' lower thighs, as recommended by (Rojas-Palma 2009). Figure 1 illustrates the measurement to obtain C, to the left and to obtain CB, to the right.

All preparations preceding the start of the monitoring program such as personal resources, instruments' readiness, location, access to decontamination facilities, etc. must be covered by the preparedness plans of the responders to nuclear emergencies.

Figure 1: Illustration for thyroid (C) and corresponding body background (CB) measurement, as recommended in TMT handbook (Rojas-Palma 2009)


Begin
measure the average environmental background count rate, B
measure the average thyroid count rate, C
C > 2 x B ?
No
thyroid contamination not found
End
Yes
measurement of the average body background count rate, CB
Yes
decontami-nation procedure
C > 2 x CB ?
No
thyroid contamination not found
End
Yes
check for skin/clothes contamination
Yes
Is contamination larger than 2CB?
No
C - CB ≥ "no exposure"? (tables 9, 12, 15)
No
thyroid contamination not found
End
Yes
"no exposure" < C – CB ≤ AL_L? (tables 8,11,14)
Yes
thyroid contamination is present
Action level 1
End
No
AL_L < C – CB ≤ AL_U ? (tables 8,11,14)
Yes
thyroid contamination is present
Action level 2
End
No
C – CB > AL_U ? (tables 8,11,14)
Yes
thyroid contamination is present
Action level 3
End
End

1.3. Intake of stable iodine

The intake of stable iodine pills will block the accumulation of radioactive iodine in the thyroid. If stable iodine is administered before the exposure to the radioactive plum containing radioiodines, all radioactive iodine will be blocked. If, however, stable iodine is administered more than 10 h after the exposure, the values provided in tables 1 – 4 and 7 – 15 in this guide should be used with caution since the blocking factor can be highly variable.

1.4. Contribution of other radionuclides to the thyroid dose

The contribution to the equivalent thyroid dose from ingestion of long-lived radionuclides such as cesium-137 is small and can be considered negligible if proper food restrictions have been put in place (Minenko 2006). The contribution from the external exposure coming from the ground deposition is also small and depends on the geographical distribution of this deposition and should be assessed based on measurement data (Minenko 2006).

Three other radioactive isotopes of iodine and two precursor isotopes of tellurium behave in the reactor, in the environment, and the human body similarly to ^{131}I. These are ^{132}I (2.3 h), ^{133}I (20.8 h), ^{135}I (6.6 h), ^{131m}Te (30 h) precursor of ^{131}I and ^{132}Te (78.2 h) precursor of ^{132}I. The contributions to the equivalent thyroid dose from ^{133}I and ^{135}I have been found both in Chernobyl and Fukushima to be well under 1 % of the contribution from ^{131}I (Shinkarev 2014).

For the case of ^{132}I and its precursor ^{132}Te, the contribution to the thyroid dose is determined by the dominant pathway of the internal contamination. In Chernobyl the consumption of local cow milk was the main pathway and the contribution to the equivalent thyroid dose from ^{132}I and ^{132}Te ranged between 2 – 5 % of the contribution of ^{131}I (Gavrilin 2004).

If the dominant pathway for the internal contamination is inhalation, as it was in Fukushima, depending on the ratio ^{132}Te/^{131}I at reactor shutdown and because of the main form of ^{132}Te is aerosol, the contribution to the equivalent thyroid dose may be considerable higher. In the Fukushima scenario it has been found that ^{132}I and ^{132}Te these contributed to the equivalent thyroid dose by up to 40 % of the contribution from ^{131}I, for one year old children (Shinkarev 2014).

If the presence of short-lived radioiodines such as ^{132}I, ^{133}I, ^{135}I is not considered, instruments that show a reading as count rate in cps would overestimate the committed effective dose just after a reactor release. From 12 hours and after the release, the contribution to the instruments reading from short-lived radioiodines and short-lived radiotelluriums can be considered negligible, except for ^{131}I.

2. From monitored activity in the thyroid to the effective dose

2.1. General assumptions

Different quantities can be measured depending on the instruments that are used. A net count rate in units of cps is recorded by most intensimeters. Also dose rate meters displaying µSv/h can be used. The instrument's reading can be converted to thyroid ^{131}I activity in Becquerel by applying the proper calibration factor. For a calibration procedure example regarding ^{131}I in thyroids see (Nyander P. 2014). The activity obtained is, however, NOT the actual intake but the ^{131}I activity that has accumulated in the thyroid at the measurement time.

The biokinetics of ^{131}I is described in the ICRP Publication 56 by a three-compartment model (ICRP 1990), see Figure 2. After entering the blood, either from the gastrointestinal tract or from the lungs (ingestion or inhalation), ^{131}I is accumulated and thereafter cleared. The recycling of iodine is due to the production of hormone in the thyroid gland, which is circulated in the body.

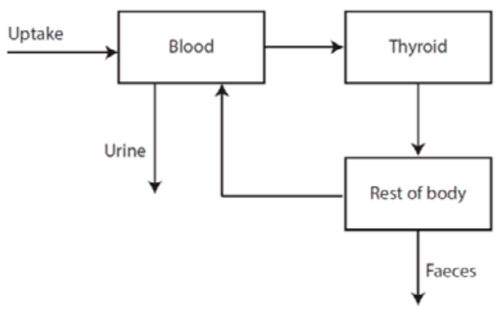


Figure 2. Three-compartment model of iodine biokinetics, from ICRP 56.

Inhalation of iodine in particulate form will result in absorption of 30 – 40 % into the blood, depending on the particle size and solubility in the lungs. Different chemical forms of iodine, aerosol particle size and solubility will influence the result of the calculation of committed equivalent thyroid dose and committed effective dose. Figure 3 shows the retention, including physical decay, of ^{131}I in the thyroid after intake of 1 Bq from inhalation and ingestion, respectively.

The retention curve for e.g. inhalation shows the fraction of the inhaled activity in the thyroid at various times after intake. If the time of intake is known it is then possible to determine the inhaled activity from a measurement of the activity in the thyroid.

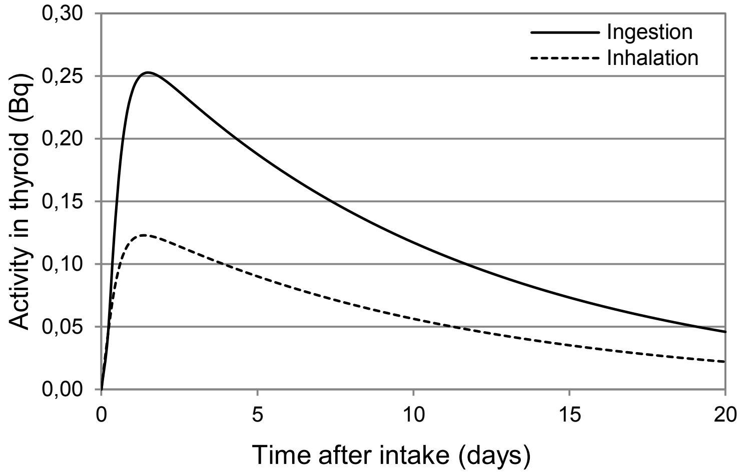


Figure 3. Retention and clearance of ^{131}I after an intake of 1 Bq via ingestion and inhalation.

2.2. Committed effective dose per unit of the activity accumulated in the thyroid at monitoring time

The committed effective dose is calculated by dose coefficients from ICRP report 119 (ICRP 2012). In Figure 4 the dose coefficients are shown graphically. Table 1 contain the values of the dose coefficient (mSv/Bq) for various age groups, relating the measured ^{131}I activity in the thyroid at various times after intake to the committed effective dose.

The data from Table 1 may be used in case of a reactor release, if the time between release and measurement is more than 12 h. Otherwise; the measurement will be disturbed by the presence of short-lived iodine isotopes. In case of a laboratory accident, where only ^{131}I is handled, the data may be used from 1 hour after inhalation.

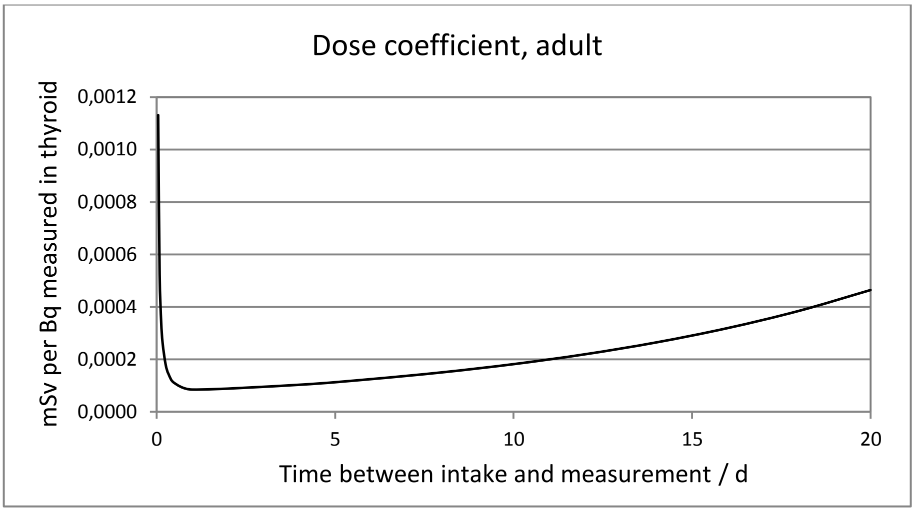


Figure 4. Dose coefficients (mSv per Bq) for adults, showing a minimum at 1 d after intake due to the shape of the retention function. The activity refers to the ^{131}I activity measured in the thyroid at the specified time after intake and the dose refers to the effective dose.

Assuming that the dose to the thyroid dominates among other contributions to the effective dose, the thyroid committed equivalent dose is obtained by dividing the committed effective dose by the organ weighting factor, w_T, for the thyroid, which is 0.05 (ICRP 2007).

Table 1. Dose coefficients (mSv per Bq) for various age groups calculated from the retention function and dose coefficients given in ICRP report 119 (ICRP, 2012). The activity given here is the ^{131}I activity measured in the thyroid at the specified time after intake.

	Dose coefficient (mSv per Bq)				
Time elapsed between intake and monitoring	Infants & <1 a	5 a	10 a	15 a	Adult
1 hour	0.011	0.0057	0.0029	0.0017	0.0011
2 hours	0.0051	0.0026	0.0013	0.00078	0.00052
3 hours	0.0034	0.0017	0.00089	0.00052	0.00035
4 hours	0.0026	0.0013	0.00067	0.00039	0.00026
6 hours	0.0018	0.00091	0.00047	0.00027	0.00018
8 hours	0.0014	0.00072	0.00037	0.00021	0.00014
12 hours	0.0011	0.00055	0.00028	0.00016	0.00011
1 day	0.00083	0.00043	0.00022	0.00013	0.00009
4 days	0.0010	0.00052	0.00027	0.00015	0.00010
6 days	0.0012	0.00062	0.00032	0.00019	0.00012
8 days	0.0015	0.00075	0.00039	0.00022	0.00015
10 days	0.0018	0.00091	0.00047	0.00027	0.00018
12 days	0.0021	0.0011	0.00056	0.00033	0.00022
14 days	0.0026	0.0013	0.00068	0.00039	0.00026
16 days	0.0031	0.0016	0.00082	0.00047	0.00032
18 days	0.0037	0.0019	0.0010	0.00057	0.00039
20 days	0.0045	0.0023	0.0012	0.00069	0.00046

2.3. Threshold values corresponding to action levels

The activities measured during thyroid monitoring corresponding to the lower (20 mSv) and upper (200 mSv) action levels, are given in Table 2 and Table 3 respectively. These values are 20 and 200 times the inverted values from Table 1, respectively.

The data from Table 2 & 3 may be used in case of a reactor release, if the time between release and measurement is more than 12 h. Otherwise; the measurement will be disturbed by the presence of short-lived iodine isotopes. In case of a laboratory accident, where only ^{131}I is handled, the data may be used from 1 hour after inhalation.

Table 2. Activity (in kBq) measured in the thyroid at various times after intake, corresponding to an intake that will give a committed effective dose of 20 mSv.

	Measured activity in thyroid (kBq)				
Time elapsed between intake and monitoring	Infants & <1 a	5 a	10 a	15 a	Adult
1 hour	1.8	3.5	6.9	11.9	17.7
2 hours	3.9	7.6	14.9	25.7	38.1
3 hours	5.9	11.5	22.5	38.8	57.7

4 hours	7.8	15.3	29.7	51.3	76.3
6 hours	11.3	22.0	42.9	74.0	110.1
8 hours	14.3	27.8	54.1	93.5	138.9
12 hours	18.7	36.5	71.0	122.6	182.3
1 day	24.2	47.0	91.6	158.2	235.1
4 days	19.9	38.7	75.3	130.1	193.4
6 days	16.5	32.0	62.4	107.7	160.1
8 days	13.6	26.5	51.7	89.2	132.6
10 days	11.3	22.0	42.8	73.9	109.9
12 days	9.4	18.2	35.5	61.3	91.1
14 days	7.8	15.1	29.4	50.8	75.5
16 days	6.4	12.5	24.4	42.1	62.6
18 days	5.3	10.4	20.2	34.9	51.9
20 days	4.4	8.6	16.8	29.0	43.1

Table 3. Activity (in kBq) measured in the thyroid at various times after intake, corresponding to an intake that will give a committed effective dose of 200 mSv.

	Measured activity in thyroid (Bq)				
Time elapsed between intake and monitoring	Infants & <1 a	5 a	10 a	15 a	Adult
1 hour	18.2	35.4	68.9	118.9	176.8
2 hours	39.2	76.3	148.6	256.6	381.4
3 hours	59.3	115.4	224.7	388.1	576.9
4 hours	78.4	152.5	297.0	513.1	762.6
6 hours	113.1	220.1	428.6	740.4	1100.5
8 hours	142.8	277.8	541.0	934.5	1389.2
12 hours	187.3	364.5	709.9	1226.1	1822.6
1 day	241.7	470.3	915.8	1581.8	2351.3
4 days	198.8	386.8	753.2	1301.0	1934.0
6 days	164.6	320.2	623.6	1077.2	1601.2
8 days	136.3	265.2	516.5	892.1	1326.2
10 days	112.9	219.7	427.9	739.1	1098.7
12 days	93.6	182.1	354.6	612.6	910.6
14 days	77.6	151.0	294.0	507.8	754.9
16 days	64.3	125.2	243.8	421.1	625.9
18 days	53.4	103.8	202.2	349.2	519.1
20 days	44.3	86.1	167.7	289.7	430.6

2.4. “No thyroid exposure” level

The “no thyroid exposure” is the activity measured during thyroid monitoring assumed to give a committed effective dose of 1 mSv as maximum. It can be determined as the inverse of the values in Table 1. This data in Table 4 may be used in case of a reactor release, if the time between release and measurement is more than 12 h. Otherwise; the measurement will be disturbed by the presence of short-lived iodine isotopes. In case of a laboratory accident, where only ^{131}I is handled, the data may be used from 1 hour after inhalation.

Table 4. Activity (in kBq) measured in the thyroid at various times after intake, corresponding to an intake that will give a committed effective dose of 1 mSv.

	Measured activity in thyroid (kBq)				
Time between intake and monitoring	Infants & <1 a	5 a	10 a	15 a	Adult
1 hour	0.091	0.177	0.344	0.595	0.884
2 hours	0.196	0.381	0.743	1.283	1.907
3 hours	0.296	0.577	1.123	1.94	2.884
4 hours	0.392	0.763	1.485	2.565	3.813
6 hours	0.566	1.101	2.143	3.702	5.503
8 hours	0.714	1.389	2.705	4.673	6.946
12 hours	0.937	1.823	3.549	6.131	9.113
1 day	1.208	2.351	4.579	7.909	11.757
4 days	0.994	1.934	3.766	6.505	9.67
6 days	0.823	1.601	3.118	5.386	8.006
8 days	0.682	1.326	2.583	4.461	6.631
10 days	0.565	1.099	2.14	3.696	5.494
12 days	0.468	0.911	1.773	3.063	4.553
14 days	0.388	0.755	1.47	2.539	3.774
16 days	0.322	0.626	1.219	2.105	3.13
18 days	0.267	0.519	1.011	1.746	2.596
20 days	0.221	0.431	0.839	1.448	2.153

3. Dose conversion coefficients for selected instruments

The instruments in this report were selected from those calibrated under the Nordic project THYROID in 2014 (Nyander P. 2014). The measured quantities were count rate in units of cps, for counters, spectrometers and gamma cameras, and ambient dose rate in units of µSv/h, for dose rate meters. Table 5 summarizes the main features of example instruments.

Table 5. Main features of example instruments (Nyander P., 2014). MCA stands for signal handling by multichannel analyser.

Instrument	Type	Technical specifications		
		Detector	Volume (mm^3)	Electronic
SAIC Exploranium GR-135	Spectrometer	NaI	65	MCA
FLIR IdentiFINDER2	Dose rate meter	NaI	49	MCA
Theo10	Spectrometer	NaI	110	MCA

The calibration factors for activity in thyroid given, as example, in Table 6 serve only as a guide. The calibration of these instruments was performed using mock-iodine as a substitute for ^{131}I. The mock-iodine consists of a mix of ^{133}Ba and ^{137}Cs and the calibration factor will depend on the settings of energy range for each individual instrument. The calibration factors given in Table 6 are corrected to show the activity of ^{131}I. A discussion of this correction is given in (Nyander P. 2014).

Table 6. Example calibration factors for the instruments described in Table 5.

Instrument	Unit	Calibration distance (cm)	Calibration factor		
			Child (5 y)	Young (13 – 16y)	Adult (over 18y)
SAIC Exploranium GR-135	Bq per cps	0	50	71	110
FLIR IdentiFINDER	Bq per µSv/h	0	15843	20622	35634
Theo10	Bq per cps	10	813	902	1021

The Tables 7 – 15 list the conversion factors to obtain the committed effective dose per unit of the measurement quantity, and the values of the measurements quantities corresponding to the upper, lower and “no exposure” dose levels, at different time intervals between intake and monitoring, for children, young and adults.

Tables 7 – 9 correspond to the counter Exploranium GR-135, monitoring at close distance; Tables 10 -13 to the dose rate meter IdentiFINDER, monitoring at close distance; Tables 13 – 15 correspond to the uptake meter Theo10, monitoring at 10 cm away from the neck.

In case the main contribution to the effective dose is just the thyroid dose, to obtain the committed equivalent dose to the thyroid the values in tables 7, 10 and 13 should be multiply by a factor of 20.

3.1 Exploranium GR-135

3.1.1. Committed effective dose per unit of the measurement quantity

Table 7. Committed effective dose per units of the net monitored count rate with the spectrometric instrument **Exploranium GR-135** monitoring at close distance

	Dose conversion factor for **Exploranium GR-135** monitoring at close distance (mSv per cps)		
Time from suspected intake to monitoring	Child (5 y)	Young (13 – 16y)	Adult (over 18y)
1 hour	0.283	0.119	0.124
2 hours	0.131	0.055	0.058
3 hours	0.087	0.037	0.038
4 hours	0.066	0.028	0.029
6 hours	0.045	0.019	0.020
8 hours	0.036	0.015	0.016
12 hours	0.027	0.012	0.012
1 day	0.021	0.009	0.009
4 days	0.026	0.011	0.011
6 days	0.031	0.013	0.014
8 days	0.038	0.016	0.017
10 days	0.046	0.019	0.020
12 days	0.055	0.023	0.024
14 days	0.066	0.028	0.029
16 days	0.080	0.034	0.035
18 days	0.096	0.041	0.042
20 days	0.116	0.049	0.051

3.1.2. Threshold values corresponding to the action levels

Table 8. Net count rate thresholds corresponding to the upper and lower action levels (AL_U = 200 mSv, AL_L = 20 mSv) for the spectrometric instrument **Exploranium GR-135** monitoring at close distance

	Thresholds for **Exploranium GR-135** monitoring at close distance (cps)					
	Upper action level			Lower action level		
Time from suspected intake to monitoring	Child (5 y)	Young (13 – 16y)	Adult (over 18y)	Child (5 y)	Young (13 – 16y)	Adult (over 18y)
1 hour	707	1675	1607	71	167	161
2 hours	1526	3614	3468	153	361	347
3 hours	2308	5466	5244	231	547	524

4 hours	3051	7226	6933	305	723	693
6 hours	4402	10428	10005	440	1043	1000
8 hours	5557	13162	12629	556	1316	1263
12 hours	7290	17269	16569	729	1727	1657
1 day	9405	22279	21376	941	2228	2138
4 days	7736	18324	17582	774	1832	1758
6 days	6405	15171	14556	640	1517	1456
8 days	5305	12565	12056	530	1257	1206
10 days	4395	10410	9988	439	1041	999
12 days	3642	8628	8278	364	863	828
14 days	3019	7152	6862	302	715	686
16 days	2504	5931	5690	250	593	569
18 days	2077	4919	4719	208	492	472
20 days	1722	4080	3915	172	408	391

3.1.3. “No thyroid exposure” values

Table 9. Maximum net count rate to confirm a “no thyroid exposure” level (E ≤ 1 mSv) for the dose rate meter **Exploranium GR-135** monitoring at close distance

	No thyroid exposure level for **Exploranium GR-135** monitoring at close distance (cps)		
Time from suspected intake to monitoring	Child (5 y)	Young (13 – 16y)	Adult (over 18y)
1 hour	3.54	8.37	8.04
2 hours	7.63	18.07	17.34
3 hours	11.54	27.33	26.22
4 hours	15.25	36.13	34.67
6 hours	22.01	52.14	50.02
8 hours	27.78	65.81	63.14
12 hours	36.45	86.35	82.85
1 day	47.03	111.39	106.88
4 days	38.68	91.62	87.91
6 days	32.02	75.86	72.78
8 days	26.52	62.83	60.28
10 days	21.97	52.05	49.94
12 days	18.21	43.14	41.39
14 days	15.10	35.76	34.31
16 days	12.52	29.65	28.45
18 days	10.38	24.59	23.60
20 days	8.61	20.40	19.57

3.2 IndentiFinder

3.2.1. Committed effective dose per unit of the measurement quantity

Table 10 Committed effective dose per units of the net monitored dose rate with the dose rate meter **IdentiFinder** monitoring at close distance

	Dose conversion factor for **IdentiFinder** monitoring at close distance (mSv per µSv/h)		
Time from suspected intake to monitoring	Child (5 y)	Young (13 – 16y)	Adult (over 18y)
1 hour	89.62	34.68	40.31
2 hours	41.54	16.07	18.68
3 hours	27.46	10.63	12.35
4 hours	20.77	8.04	9.34
6 hours	14.40	5.57	6.48
8 hours	11.40	4.41	5.13
12 hours	8.69	3.36	3.91
1 day	6.74	2.61	3.03
4 days	8.19	3.17	3.69
6 days	9.89	3.83	4.45
8 days	11.95	4.62	5.37
10 days	14.42	5.58	6.49
12 days	17.40	6.73	7.83
14 days	20.99	8.12	9.44
16 days	25.31	9.79	11.39
18 days	30.52	11.81	13.73
20 days	36.79	14.24	16.55

3.2.2. Threshold values corresponding to the action levels

Table 11. Net dose rate thresholds corresponding to the upper and lower action levels (AL_U = 200 mSv, AL_L = 20 mSv) for the dose rate meter **IdentiFinder** monitoring at close distance

	Thresholds for **IdentiFinder** monitoring at close distance (µSv/h)					
	Upper action level			Lower action level		
Time from suspected intake to monitoring	Child (5 y)	Young (13 – 16y)	Adult (over 18y)	Child (5 y)	Young (13 – 16y)	Adult (over 18y)
1 hour	2.23	5.77	4.96	0.22	0.58	0.50
2 hours	4.82	12.44	10.70	0.48	1.24	1.07
3 hours	7.28	18.82	16.19	0.73	1.88	1.62
4 hours	9.63	24.88	21.40	0.96	2.49	2.14
6 hours	13.89	35.90	30.88	1.39	3.59	3.09
8 hours	17.54	45.32	38.98	1.75	4.53	3.90
12 hours	23.01	59.46	51.15	2.30	5.95	5.11
1 day	29.68	76.70	65.99	2.97	7.67	6.60
4 days	24.41	63.09	54.27	2.44	6.31	5.43
6 days	20.21	52.23	44.93	2.02	5.22	4.49
8 days	16.74	43.26	37.22	1.67	4.33	3.72

10 days	13.87	35.84	30.83	1.39	3.58	3.08
12 days	11.49	29.70	25.55	1.15	2.97	2.56
14 days	9.53	24.63	21.18	0.95	2.46	2.12
16 days	7.90	20.42	17.57	0.79	2.04	1.76
18 days	6.55	16.94	14.57	0.66	1.69	1.46
20 days	5.44	14.05	12.08	0.54	1.40	1.21

3.1.3. “No thyroid exposure” values

Table 12. Maximum net count rate to confirm a “no thyroid exposure” level (E ≤ 1 mSv) for the dose rate meter Identifiender monitoring at close distance

	No thyroid exposure level for **IdentiFinder** monitoring at close distance (µSv/h)		
Time from suspected intake to monitoring	Child (5 y)	Young (13 – 16y)	Adult (over 18y)
1 hour	0.011	0.029	0.025
2 hours	0.024	0.062	0.054
3 hours	0.036	0.094	0.081
4 hours	0.048	0.124	0.107
6 hours	0.069	0.180	0.154
8 hours	0.088	0.227	0.195
12 hours	0.115	0.297	0.256
1 day	0.148	0.384	0.330
4 days	0.122	0.315	0.271
6 days	0.101	0.261	0.225
8 days	0.084	0.216	0.186
10 days	0.069	0.179	0.154
12 days	0.057	0.149	0.128
14 days	0.048	0.123	0.106
16 days	0.040	0.102	0.088
18 days	0.033	0.085	0.073
20 days	0.027	0.070	0.060

3.3 Uptake meter THEO 10

3.3.1. Committed effective dose per unit of the measurement quantity

Table 13. Committed effective dose per units of the net monitored count rate with the **uptake meter Theo10** monitoring at 10 cm distance from the neck

	Dose conversion factor for **Theo10** monitoring 10 cm distance from the neck (mSv per cps)		
Time from suspected intake to monitoring	Child (5 y)	Young (13 – 16y)	Adult (over 18y)
1 hour	4.60	1.52	1.16
2 hours	2.13	0.70	0.54
3 hours	1.41	0.46	0.35
4 hours	1.07	0.35	0.27
6 hours	0.74	0.24	0.19
8 hours	0.59	0.19	0.15
12 hours	0.45	0.15	0.11
1 day	0.35	0.11	0.09
4 days	0.42	0.14	0.11
6 days	0.51	0.17	0.13
8 days	0.61	0.20	0.15
10 days	0.74	0.24	0.19
12 days	0.89	0.29	0.22
14 days	1.08	0.36	0.27
16 days	1.30	0.43	0.33
18 days	1.57	0.52	0.39
20 days	1.89	0.62	0.47

3.3.2. Threshold values corresponding to the action levels

Table 14. Net count rate thresholds corresponding to the upper and lower action levels (AL_U = 200 mSv, AL_L = 20 mSv) for the **uptake meter Theo10** monitoring at 10 cm distance from the neck

	Thresholds for **Theo10** monitoring at 10 cm distance (cps)					
	Upper action level			Lower action level		
Time from suspected intake to monitoring	Child (5 y)	Young (13 – 16y)	Adult (over 18y)	Child (5 y)	Young (13 – 16y)	Adult (over 18y)
1 hour	43	132	173	4.35	13.18	17.31
2 hours	94	284	374	9.38	28.45	37.36
3 hours	142	430	565	14.19	43.03	56.50
4 hours	188	569	747	18.76	56.88	74.70
6 hours	271	821	1078	27.07	82.08	107.79
8 hours	342	1036	1361	34.17	103.61	136.06
12 hours	448	1359	1785	44.84	135.93	178.51
1 day	578	1754	2303	57.84	175.37	230.30
4 days	476	1442	1894	47.58	144.24	189.42
6 days	394	1194	1568	39.39	119.42	156.83

8 days	326	989	1299	32.62	98.91	129.89
10 days	270	819	1076	27.03	81.95	107.61
12 days	224	679	892	22.40	67.91	89.18
14 days	186	563	739	18.57	56.30	73.93
16 days	154	467	613	15.40	46.68	61.30
18 days	128	387	508	12.77	38.72	50.85
20 days	106	321	422	10.59	32.12	42.18

3.3.3. “No thyroid exposure” values

Table 15. Maximum net count rate to confirm a “no thyroid exposure” level (E ≤ 1 mSv) for the **uptake meter Theo10** monitoring 10 cm distance from the neck

	No thyroid exposure level for **Theo10** monitoring 10 cm distance (cps)		
Time from suspected intake to monitoring	Child (5 y)	Young (13 – 16y)	Adult (over 18y)
1 hour	0.22	0.66	0.87
2 hours	0.47	1.42	1.87
3 hours	0.71	2.15	2.83
4 hours	0.94	2.84	3.73
6 hours	1.35	4.10	5.39
8 hours	1.71	5.18	6.80
12 hours	2.24	6.80	8.93
1 day	2.89	8.77	11.51
4 days	2.38	7.21	9.47
6 days	1.97	5.97	7.84
8 days	1.63	4.95	6.49
10 days	1.35	4.10	5.38
12 days	1.12	3.40	4.46
14 days	0.93	2.81	3.70
16 days	0.77	2.33	3.07
18 days	0.64	1.94	2.54
20 days	0.53	1.61	2.11

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The Authority reports to the Ministry of the Environment and has around 300 employees with competencies in the fields of engineering, natural and behavioural sciences, law, economics and communications. We have received quality, environmental and working environment certification.

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