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Abstract

Dose calculations have been performed for accidental releases of tritium and activation products. Unit releases of 1 GBq per nuclide have been investigated for 31 fusion relevant nuclides. Additionally, unit releases of 1g of tritium and several activated materials have been studied. Under normal operation conditions, dose calculations have been performed for real source terms of tritium and activated materials. The individual dose values at the fence of the site (1 km) as well as the collective dose to the public (from 1 km to 100 km) have been obtained. As site specific parameters are still missing, different so called 'worst case' release conditions have been applied. To have a first guess of the influence of the release duration on the dose to the Most Exposed Individual (MEI) in the vicinity of a reactor, different release durations, ranging from 1 hour up to 168 hours have been investigated, too. Finally, dose calculations have been performed for mobilisation source terms which take account of deposition and retention in the plant. This has been done for several RPM and APM source terms. The dose values of these final source terms seem to be less than every criteria to start emergency actions, however, some problems e.g. the behaviour of tritium in the plant, remain unsolved.

Ergebnisse der SEAFP Studie, Teilbereich A10: Abschätzung von Individual- und Kollektivdosen für Freisetzungen von Tritium und Aktivierungsprodukten bei potentiellen Unfällen und während des Normalbetriebs.

Zusammenfassung

Im Rahmen der SEAFP Studie wurden Dosisabschätzungen für Tritium und Aktivierungsprodukte durchgeführt. Dabei wurden Einheitsfreisetzungen von jeweils einem GBq für insgesamt 31 verschiedene fusionsrelevante Radionuklide untersucht, zusätzlich dazu Dosisabschätzungen für unfallbedingte Freisetzungen von einem Gramm Tritium und verschiedenen anderen Materialien. Es wurden weiterhin realistische Quellterme untersucht, die während des Normalbetriebs einer Anlage auftreten können. Berechnet wurden die Individualdosis am Zaun (1 km) sowie die Kollektivdosis der Bevölkerung in der Umgebung der Anlage (1 km - 100 km). Da spezielle anlagenspezifische Ausbreitungsbedingungen nicht verfügbar waren, wurden sogenannte 'worst case' Freisetzungsbedingungen angenommen. Um einen Überblick über den Einfluß der Freisetzungszeit auf die maximale Individualdosis am Zaun zu erzielen, wurden Freisetzungszeiten zwischen einer Stunde und sieben Tagen gewählt. Nachdem auch für unfallbedingte Freisetzungen quasi realistische Quellterme zur Verfügung standen, die Ablagerungen in der Anlage mitberücksichtigten, wurden für diese neue Rechnungen durchgeführt. Hierbei dienten die beiden SEAFP Anlagenkonzepte APM und RPM als Basis der Untersuchungen. Die Dosen, die aus diesen quasi realistischen Quelltermen resultieren, liegen weit unterhalb jedes Eingreifwertes. Allerdings sind noch einige der Prozesse, die zum endgültigen Quellterm beitragen, wie z. B. die Ablagerung des Tritiums in der Reaktoranlage selbst, nicht zufriedenstellend gelöst worden. Eine weitere Untersuchung dieser offenen Fragen mit anschließender neuer Dosisberechnung erscheint wünschenswert.

Table of Contents

1. Introduction

In view of the public acceptance and the licensing procedure of projected fusion reactors, the release of tritium and activation products during normal operation as well as after accidents is a significant safety aspect. Therefore, one of the main design objectives for a future fusion reactor is to minimise the potential off-site consequences to the public from potential accidental releases as well as for releases under normal conditions. There are several possibilities to achieve the objectives e.g. active safety systems, passive safety systems and reduction of in-plant inventories. To provide the relevant information to the designers the relationship between released activity and the dose burden to the public has to be determined. However, in the current stage of planning, a lot of uncertainties, such as the site for a fusion reactor and the final design prevent dose assessments required for regulatory purposes. Therefore, dose calculations have been performed mainly for nuclide specific unit release source terms which can be easily combined and scaled if realistic source terms become available. The resulting individual dose values at the fence of the site as well as the collective dose to the public can be used to backcalculate the maximum amount of radioactivity which can be released without exceeding recommended dose limits. As site specific parameters are still missing, different environmental release conditions, representing worst case weather conditions, have been investigated.

To have a first guess of the influence of the release duration on the dose to the Most Exposed Individual (MEI) in the vicinity of a reactor, different release durations, ranging from 1 hour up to 168 hours, have been considered. Additionally, source terms taking into account the mobilisation and retention processes in the plant and the leaking over a longer period have been investigated.

2. Model description

2.1 Tritium models

The computer program UFOTRI /RAS90, RAS93/ for assessing the radiological consequences of accidental tritium releases has been used for the dose assessments. UFOTRI is a computer code for both determinisitic and probabilistic assessments. For atmospheric dispersion and deposition calculations (dry and wet) a modified version of the trajectory model MUSEMET /STR81/ is implemented in UFOTRI. Processes such as the conversion in the soil of tritium gas (HT) into tritiated water (HTO), reemission after deposition and the conversion of HTO into organically bound tritium are considered. During a time period of some days, all the relevant transfer processes between the compartments of the biosphere (atmosphere, soil, plants, animals) are described dynamically. A first order compartment model calculates the longer term pathway of tritium in the foodchains. In its newest version all the exchange processes (atmosphere-soil; atmosphere-plant) are based on resistance approaches and are re-evaluated during the calculations dependent on the prevailing environmental conditions. A simple photosynthetic submodule, which calculates the actual transfer rate of HTO in plant water into organically bound tritium improved the results for the ingestion pathways.

Releases under normal operation conditions have been performed with the model NORMTRI /RAS93b/. The doses from inhalation and skin absorption are calculated dependent on the mean tritium concentration in air above ground within 1 year. The tritium concentrations in foodstuffs are derived from both, the mean HTO concentrations in air and the HTO concentration in precipitation water, with the relative air humidity as the steering factor. Deposited tritium HT/HTO (HT is converted rapidly into HTO) is reemitted again into the atmosphere and dispersed again during the selected time period. NORMTRI is based on a statistical Gaussian atmospheric dispersion model (ISOLA V /HUE90/). This means, for all different dispersion situations during the considered time period, a double Gaussian distribution of the released radionuclides is assumed for the activity concentration in the plume. The data file, covering one year, contains meteorological parameters such as wind speed, wind direction, stability class and rain intensity in hourly values.

2.2 Activation product models

Calculations for accidental released activation products were performed with a special version of the program system COSYMA /COS90/ (subsystem NL), which contains extended data sets for activation products. For atmospheric dispersion and deposition calculations (dry and wet) a modified version of the trajectory model MUSEMET is implemented in COSYMA as in UFOTRI. It was assumed, that the nuclides which appear in aerosol form have a mean diameter of 1 mm AMAD, and that the corresponding dry deposition velocity is 0.001 m/s (see also Table 12). To have a rough estimation of the radiological impact from nuclides not yet implemented in COSYMA, a simplified program version has been generated which allows dose assessments for up to about 290 nuclides, however for potential EDE only. In this version, the ingestion pathway is modelled by a set of equations from the German regulatory guidelines /BUN90/, which allow only a rough estimation of the ingestion dose. The doses by ingestion of contaminated foodstuffs are calculated assuming the local production and consumption method; that means, all foodstuffs are consumed in the grid element where they are harvested / produced. The program system COSYMA has been applied also for releases under normal operation conditions. To that purpose, the trajectory model was replaced by the statistical Gaussian atmospheric model ISOLA V, also used within NORMTRI.

3 Accident consequence assessment

3.1 Release conditions

Within previous investigations of releases near the ground level, a worst case weather sequence (called 4826) has been identified to result in the highest dose values for activation products /RAS92 /. For tritium, especially for HTO, another weather sequence (called 2791) has been found to be the most hazardous for releases near the ground surface. As the releases near the ground always result in higher doses at the fence, only the weather sequence 4826 has been applied for all accidental source terms. This weather sequence results also in very high doses if the release occurs from the stack. This is due to rain in the first hour which causes a high deposition flux to the ground even if the plume itself has not touched the ground surface. To have a first guess of the doses which result from stack releases without any rain, parameter studies have been performed to identify the situation which gives the highest dose in 1 km distance, assuming a stack height of 150 m. To quantify the difference between the two weather sequences 4826 and 2791, comparative dose calculations have been performed for several activation products and tritium. This includes one nuclide from the group of noble gases, iodine and aerosols.

Individual potential doses (no shielding) together with the contribution of the 5 pathways internal exposure from inhalation (IH), inhalation from resuspension (IHR), and ingestion (IG), and external irradiation from cloud (CL) and ground (GR), have been calculated for the Most Exposed Individual (MEI) at 1 km distance from the source, which might be the proposed fence distance for a fusion reactor. Additionally, the collective dose from 1 km up to 100 km distance has been obtained. The population distribution was assumed to be uniform with 250 people living per square kilometer. The basic input parameters for the accidental release scenarios are presented in Tables 1 and 2. The release duration was set to 1 hour. The dispersion parameter set 'Mol' /BUL72/ was used. It is representative for a 1 hour release time and a roughness length of about 30 cm.

parameter	value
individual dose at 1 km	Most Exposed Individual (MEI) at 1 km
collective dose (1 to 100 km)	CEDE
population density	250 People/km**2
building dimensions (h x w)	60m x 100m
release rate	1 GBq per nuclide or as specified
release duration	1 hr
washout coefficient (w)	w = A*I**B (1/s)
rain intensity I	mm/hr
coefficient A (HTO)	9.0 E-05 (hr/mm)/s
coefficient B (HTO)	0.6
coefficient A (HT)	0.0 (hr/mm)/s
coefficient B (HT)	0.0
coefficient A (noble gas)	0.0 (hr/mm)/s
coefficient B (noble gas)	0.0
coefficient A (aerosol)	8.0 E-05 (hr/mm)/s
coefficient B (aerosol)	0.8
coefficient A (iodine elemental)	8.0 E-05 (hr/mm)/s
coefficient B (iodine elemental)	0.6
coefficient A (iodine organic)	8.0 E-07 (hr/mm)/s
coefficient B (iodine organic)	0.6
coefficient A (iodine aerosol)	8.0 E-05 (hr/mm)/s
coefficient B (iodine aerosol)	0.8
deposition velocity (tritium)	calculated by the model
deposition velocity (noble gas)	0.0 m/s
deposition velocity (aerosol)	0.001 m/s
dep. velocity (iodine elemental)	0.01 m/s
dep. velocity (iodine organic)	0.0005 m/s
dep. velocity (iodine aerosol)	0.001 m/s
breathing rate	2.66 E-4 m**3/s
skin absorption rate (tritium)	1.60 E-4 m**3/s
ingestion rate vegetables	45 kg/year
ingestion rate root vegetables	85 kg/year
ingestion rate grain products	95 kg/year
ingestion rate meat	75 kg/year
ingestion rate milk	110 kg/year
dose conversion factors	nuclide dependent
dose conversion factor IH for HT	6.8 E-16 Sv/Bq
dose conversion factor IH for HTO	1.6 E-11 Sv/Bq
dose conversion factor IG for HTO	1.6 E-11 Sv/Bq
dose conversion factor IG for OBT	4.0 E-11 Sv/Bq
shielding factor	1.0
wind speed (150m release height)	1.65 m/s

Table 1: **Main input parameters of the accidental release scenarios**, accidental release scenarios of tritium and activation products

case name	stability class (first hour)	wind speed at 10 m height (first hour)	precipitation (first hour)	solar radiation (first hour)
W2791	F	0.5 m/s	no rain	56 W /m**2
W4826	E	0.5 m/s	1.3 mm/h	0 W /m**2

Table 2: **Basic characterisation of accidental release scenarios,** realistic weather conditions which include the change of atmospheric conditions during the travel time of the plume (more data in Appendix B)

3.2. Source terms for accidental releases

Doses from unit releases of each of 31 radionuclides have been calculated as no realistic source terms were available at the beginning of the study. Lateron the following source terms (1 g) were chosen for the calculations (further reference in brackets) /FOR94a/:

1. Beryllium armour on first wall, RPM -table 1 of C. Forty - (Ber.arm. R.P)
2. V-5Ti alloy in first wall, RPM -table 3 of C. Forty - (V-5Ti R.P.)
3. Li_2O in the blanket of RPM -table 6 of C. Forty - (Li_2O R.P.)
4. Beryllium armour on first wall, APM -table 7 of C. Forty - (Ber.arm. A.P)
5. La12TaLC in first wall, APM -table 9 of C. Forty - (La12Ta A.P.)
6. MANET2 in first wall, APM -table 10 of C. Forty - (Manet2 A.P.)
7. Tritium, released as HT-gas (HT)
8. Tritium, released as tritiated water vapour (HTO)

3.3. Dose assessment

In the deterministic assessments the individual and the collective effective dose equivalent have been calculated. The individual (EDE) and collective effective dose equivalent (CEDE) result from chronic exposure and a 50 years integration time (committed dose). The exposure pathways are the external exposure from the passing cloud and the ground, the internal exposure from inhalation + skin absorption from the passing cloud (tritium only), the internal exposure from inhalation + skin absorption from reemitted material (tritium only) and the internal exposure from the ingestion of contaminated foodstuffs. The individual dose values for the MEI at a distance of 1 km as well as the collective dose between 1 km and 100 km distance have been calculated. The distance of 1 km represents the possible site boundary of a future fusion reactor.

3.3.1 Doses from accidental releases under several weather conditions (1 GBq per nuclide)

The results of the computer runs for the unit releases of each of the 31 radionuclides are documented in Appendix A. The ingestion pathway contributes most to the EDE for the nuclide tritium for all scenarios. For the activation products however, a dominating pathway can not be assigned to all nuclides (Table A1 to A6). Dependent on the dose conversion factors and the release scenario, different pathways contribute most to the EDE. As an example, the exposure pathways external irradiation from the ground and internal irradiation from inhalation are dominant for Co-60 and Be-10, respectively. The ground release conditions show in most cases higher doses in the vicinity of the source than the stack releases. The reasons are, among others, that the wind speed in 150 m height is higher than in 10 m height and the plume has not yet reached the ground surface at 1 km distance due to the narrow plume geometry. But this can differ for releases coupled with rain during the first hour. The weather sequence W4826 which does not differ fundamentally from W2791 in turbulence and wind speed, but contains rain in the first hour, shows higher EDEs at 1 km for the nuclides Co-60 and Po-210. However, this depends strongly on the importance of the exposure pathways irradiation from the ground and ingestion. For most of the activation products, the highest individual dose values at 1 km have been obtained for the case W4826 - ground release (10 m) - with stable atmospheric conditions, low wind speed and rain in the beginning, whereas for tritium, the case W2791 results in the highest EDE at 1 km.

nuclide	EDE W2791B (10m)	EDE W4826B (10m)	EDE W2791S (150m)	EDE W4826S (150m)
HT	4.24 E-10	2.73 E-10	6.60 E-13	2.12 E-12
HTO	6.40 E-09	4.30 E-09	1.03 E-11	9.61 E-10
Be-10	6.14 E-06	9.23 E-06	4.85 E-09	2.33 E-06
Ar-41	3.40 E-09	2.40 E-09	2.08 E-10	2.10 E-10
Co-60	5.50 E-05	2.35 E-04	4.39 E-08	8.06 E-05
Po-210	5.59 E-04	2.07 E-03	4.41 E-07	6.93 E-04

Table 3: **Comparison of individual doses (Sv) for the MEI at 1 km distance from 4 accidental scenarios (some selected nuclides only),** release duration 1 hr, 1.0 E+9 Bq released, two release heights (10 m and 150 m)

The dose values for the two chemical forms of tritium differ by about a factor of 15 to 20 for the four release scenarios (Table 3). When comparing the dose conversion factors of HT and HTO (Table 1) the contribution of the inhalation from the passing cloud is obviously very low for HT and the ingestion pathway is the most important one. As the ingestion pathways dominate the EDE also for HTO, the deposition velocity and the direct uptake of HT and/or HTO by the plants cause the observed difference in the EDEs by a factor of 10 and more. Direct absorption of HT by plants is negligibly small /SPE86/. The absorption of HTO is strongly dependent on the solar irradiation. Only a small fraction of HTO will be absorbed by plants if the solar radiation is very low or zero (W4826). In case of the weather sequence W2791, the solar radiation in the first hour is 56 W / m^2 , which is high enough to open the stomata and increase the direct uptake of HTO into the plants. Therefore, if the solar radiation is low (W4286), the dose value from the ingestion pathways depends mainly on the deposited activity, whereas under higher insolation (W2791) the direct uptake by the plants dominates the overall tritium concentration in the foodstuffs and results in higher EDEs.

The allocation of the collective CEDE values (between 1 km and 100 km) to nuclides and accidental scenarios show a pattern different from that of the individual dose; especially the scenario with the elevated release point and the rain event in the first hour (W4826) shows the highest collective doses for cobalt and polonium (Table 4). This might be the result of the deposition process via washout. If the release occurs from a stack (150 m) the wind speed is increased by a factor of 3 compared to a ground level release (10 m). Thus, the area which is affected by the rain and the passing cloud is much larger than for the ground release. And the larger area may then compensate the decrease in the radionuclide concentration via the increased wind speed. The contribution of the pathways for tritium and the activation products differs not significantly from the results obtained for the individual EDEs.

nuclide	CEDE W2791B (10m)	CEDE W4826B (10m)	CEDE W2791S (150m)	CEDE W4826S (150m)
HT	1.80 E-07	1.61 E-07	1.03 E-07	5.47 E-08
HTO	3.02 E-06	3.41 E-06	2.13 E-06	2.67 E-06
Be-10	9.59 E-04	1.60 E-03	5.91 E-04	1.64 E-03
Ar-41	5.76 E-07	5.97 E-07	5.12 E-07	4.46 E-07
Co-60	8.60 E-03	4.39 E-02	5.30 E-03	5.20 E-02
Po-210	8.71 E-02	3.83 E-01	5.37 E-02	4.49 E-01

Table 4: **Comparison of collective doses (manSv) between 1 km and 100 km distance for 4 accidental scenarios (some selected nuclides only),** release duration 1 year, 1.0 E+9 Bq released, two release heights (10 m and 150 m), 250 people / km^2

3.3.2 Dose assessment for accidental releases of unit source terms (1 g)

The results are listed in Tables 1 to 4. As the release fraction is still an open question, it has been assumed that 100 % of the activated material is released. This will be reduced due to deposition processes inside the reactor building. However, these mobilisation calculations are performed for the source terms documented in chapter 6

The contribution of the exposure pathways groundshine and ingestion dominate the dose values for all the 6 activation product source terms. The contribution of the exposure pathways for the EDE and the collective dose are similar. This was expected, because most of the nuclides released are of aerosol type. The variation is caused by the rain event at the beginning, which results in a high deposition rate in the near range. Except for source term 1 (Beryllium RPM) there is always one single nuclide which causes more than 50 % of the overall dose. The EDEs as well as the collective doses are higher for the APM source terms compared to the RPMs. The releases from the stack (150 m, no building wake effect) result in a dose reduction of about a factor of three compared to a release near to the ground surface (with building wake effects). The reduction is rather low, as the precipitation event causes a nonnegligible wet deposition flux to the soil surface, even if the plume has not fully reached the ground surface. In case of the absence of rain during the release time, the difference is much higher as can be seen for the tritium scenario.

The exposure pathway ingestion dominates the dose values from accidental releases of tritium in both chemical forms HT and HTO. The contribution of HT is negligibly small also in case of an HT release. The converted HTO is the dominating nuclide (99.99 %). The doses from tritium do not differ significantly when applying the two weather sequences W2791 and W4826. Thus for an intercomparison of tritium and activation products the value from the weather sequence W4826 seems to be appropriate. Under rainy conditions, the reduction factor for a stack release is about 4 for HTO but about 1000 for HT, which is due to the fact that HT is not deposited by the washout processes. Assuming dry weather conditions in the release hour the stack release shows lower doses by about a factor of 1000 compared to the ground level release. But this should not be generalized, because the difference is highly dependent on the dispersion parameter set used and the release height. Using different dispersion conditions together with a slightly modified stack height may diminish the reduction factor to a value of 10 only. Thus one has to be very careful when using a "general" reduction factor for comparing stack with ground level releases. A more detailed investigation about the maximum dose at the fence from stack releases can be found in chapter 7 of this report.

Source term (1 g)	CL (%)	GR (%)	IH (%)	IG (%)	IHR (%)	EDE (Sv)	important nuclide (% of total)
Ber. arm. (R.P.)	0.05	68.14	0.85	30.64	0.32	3.11 E-6	Co-60 (36)
V-5Ti (R.P.)	0.22	33.33	1.71	64.53	0.21	9.62 E-5	Sc-46 (57)
Li_2O (R. P.)	0.08	19.01	0.26	80.58	0.07	1.10 E-7	Zn-65 (75)
Ber. arm (A. P.)	0.03	62.93	6.25	27.92	2.88	6.49 E-6	Co-60 (54)
La12Ta (A.P.)	0.03	46.28	0.36	53.18	0.14	2.44 E-3	Mn-54 (54)
Manet 2 (A.P.)	0.04	55.72	0.43	43.64	0.17	2.17 E-3	Mn-54 (57)
HT (W4826)	0.00	0.00	0.01	99.18	0.81	1.01 E-4	HTO (100)
HT (W2791)	0.00	0.00	0.01	99.71	0.28	1.66 E-4	HTO (100)
HTO (W4826)	0.00	0.00	15.06	83.65	1.29	1.59 E-3	HTO (100)
HTO (W2791)	0.00	0.00	19.23	80.61	0.16	2.46 E+0	HTO (100)

Table 5: **EDE (Sv) at 1 km distance,** 1 g released, 10 m release height, including building wake effects, worst case weather conditions (W4826 for activation products and additionally WA-2791 for tritium)

Source term (1 g)	CL (%)	GR (%)	IH (%)	IG (%)	IHR (%)	CEDE (manSv)	important nuclide (% of total)
Ber. arm. (R.P.)	0.08	68.37	0.60	30.64	0.32	5.77 E-4	Co-60 (36)
V-5Ti (R.P.)	0.36	33.37	1.19	64.87	0.21	1.77 E-2	Sc-46 (57)
Li_2O (R. P.)	0.12	18.97	0.18	80.60	0.07	2.02 E-5	Zn-65 (75)
Ber. arm (A. P.)	0.04	64.14	4.49	28.40	2.94	1.19 E-3	Co-60 (55)
La12Ta (A.P.)	0.04	46.32	0.25	53.26	0.14	5.43 E-1	Mn-54 (54)
Manet 2 (A.P.)	0.04	55.78	0.30	43.71	0.17	4.03 E-1	Mn-54 (57)
HT (W4826)	0.00	0.00	0.00	95.64	4.95	1.36 E-1	HTO (100)
HT (W2791)	0.00	0.00	0.01	94.99	5.00	5.96 E-2	HTO (100)
HTO (W4826)	0.00	0.00	2.65	89.91	7.44	2.24 E+0	HTO (100)
HTO (W2791)	0.00	0.00	2.11	91.33	6.56	1.26 E+0	HTO (100)

Table 6: **Collective dose (manSv) between 1 and 100 km** (250 persons / km^2), 1 g released, 10 m release height, including building wake effects, worst case weather conditions (WA-4821 for activation products and additionally WA-2791 for tritium)

Source term (1 g)	CL (%)	GR (%)	IH (%)	IG (%)	IHR (%)	EDE (Sv)	important nuclide (% of total)
Ber. arm. (R.P.)	0.01	68.72	0.02	30.93	0.32	1.06 E-6	Co-60 (36)
V-5Ti (R.P.)	0.06	33.97	0.04	64.72	0.21	3.26 E-5	Sc-46 (57)
Li_2O (R. P.)	0.02	19.08	0.01	80.82	0.07	3.75 E-8	Zn-65 (75)
Ber. arm (A. P.)	0.01	67.04	0.13	29.76	3.07	2.10 E-6	Co-60 (57)
La12Ta (A.P.)	0.01	46.46	0.01	53.38	0.14	8.36 E-14	Mn-54 (54)
Manet 2 (A.P.)	0.01	55.98	0.01	43.83	0.17	7.43 E-4	Mn-54 (57)
HT (W4826)	0.00	0.00	0.01	99.25	0.74	8.10 E-7	HTO (100)
HT (W2791)	0.00	0.00	0.01	98.12	1.87	2.47 E-7	HTO (100)
HTO (W4826)	0.00	0.00	0.70	97.92	1.38	3.55 E-4	HTO (100)
HTO (W2791)	0.00	0.00	15.37	82.85	1.68	3.87 E-6	HTO (100)

Table 7: **EDE (mSv) at 1 km distance**, 1 g released, 150 m release height, no building wake effects, worst case weather conditions (WA-4821 for activation products and additionally WA-2791 for tritium)

Source term (1 g)	CL (%)	GR (%)	IH (%)	IG (%)	IHR (%)	CEDE (manSv)	important nuclide (% of total)
Ber. arm. (R.P.)	0.05	68.63	0.22	30.78	0.32	6.84 E-4	Co-60 (36)
V-5Ti (R.P.)	0.21	33.70	0.45	64.43	0.21	2.10 E-2	Sc-46 (58)
Li_2O (R. P.)	0.07	19.01	0.07	80.78	0.07	2.41 E-5	Zn-65 (75)
Ber. arm (A. P.)	0.02	66.00	1.71	29.24	3.02	1.37 E-3	Co-60 (56)
La12Ta (A.P.)	0.02	46.40	0.09	53.34	0.14	5.38 E-1	Mn-54 (54)
Manet 2 (A.P.)	0.02	55.90	0.11	43.79	0.17	4.79 E-1	Mn-54 (57)
HT (W4826)	0.00	0.00	0.01	94.81	5.18	2.02 E-2	HTO (100)
HT (W2791)	0.00	0.00	0.00	94.76	5.24	7.70 E-2	HTO (100)
HTO (W4826)	0.00	0.00	2.60	90.33	7.07	1.59 E+0	HTO (100)
HTO (W2791)	0.00	0.00	1.44	92.53	6.03	9.88 E-1	HTO (100)

Table 8: **Collective dose (manSv) between 1 and 100 km** (250 persons / km^2), 1 g released, 150 m release height, no building wake effects, worst case weather conditions (WA-4821 for activation products and additionally WA-2791 for tritium)

4. Normal operation consequence assessment

4.1 Normal operation release conditions

The meteorological data from the site of Karlsruhe were chosen as basis for the investigations on routine releases. It was found within previous investigations, that the meteorological station Karlsruhe represent moderate worst case conditions due to the channelling effect of the Rhine valley /RAS90/. The release height was set to 150 m to prevent any influence of the reactor building. The input parameters for the routine release scenario which differ from those of the accident cases are listed in Table 4.

name	release conditions	dispersion parameter set	meteorological station
SMOLKA	typical (150m):	Mol	Karlsruhe

Table 9: **Basic characterisation of the routine release scenario,** meteorological data cover 1 year with hourly values of wind speed, wind direction, stability class and rain intensity

parameter	value
release height	150 m
building dimensions	no influence
release rate	1 GBq per nuclide or as specified
release duration	1 year
relative humidity (tritium)	70 %
air humidity (tritium)	9 g/m**3
meteorological statistics (1 year)	Karlsruhe

Table 10: **Main input parameters of the routine release scenarios,** parameters not mentioned here are identical to those for the accidental scenarios

4.2 Source terms for normal operation releases

The source terms for airborne routine releases are documented in /FOR94b/. This report includes conservatively calculated discharges for the SEAFP alternative plant model (APM), which is water cooled, the reference plant model (RPM), which is helium cooled, and tritium source terms. They can be shortly characterised as (in brackets the abbreviation for further references in the Tables, reference /FOR95b/):

1. effluents from coolant loop (COOL-RPM)
2. effluents from activated nitrogen cover gas (NIT-RPM)
3. effluents from activated argon cover gas (ARG-RPM)
4. effluents from beryllium erosion dust (BER-RPM)
5. effluents from tungsten erosion dust (TUN-RPM)
6. effluents from primary coolant loops, LA12TaLC steel (LA12-APM)
7. effluents from divertor circuit loops, copper (COPD-APM)
8. effluents from activated nitrogen cover gas (NIT-APM)

9. effluents from activated argon cover gas (ARG-APM)
10. effluents from beryllium erosion dust (BER-APM)
11. effluents from tungsten erosion dust (TUN-APM)
12. effluents of tritium (T-RPM), 201 TBq HT and 46 TBq HTO
13. effluents of tritium (T-APM), 108 TBq HT and 47 TBq HTO

4.3 Dose assessment for the unit releases (1 GBq per nuclide)

The overall structure of the results is close to that from the accidental scenarios. For nuclides like tritium or cobalt, the highest dose contribution emerge from ingestion or irradiation from ground for routine as for accident releases. However, the peak concentrations are far away from the source (some kilometers) due to the elevated release point. In the vicinity of the source, the individual dose values from routine HT-releases are now by more than a factor of 50 lower than for the HTO-releases. In case of the collective doses, the difference in the dose values between the two chemical forms of tritium, HTO and HT, is only about a factor of 20.

nuclide	individual EDE	collective CEDE
HT	8.54 E-14	1.70 E-08
HTO	5.50 E-12	4.26 E-07
Be-10	8.19 E-09	5.95 E-04
Ar-41	8.79 E-12	2.98 E-07
Co-60	1.95 E-07	8.49 E-03
Po-210	1.39 E-06	5.55 E-02

Table 11: **Individual (Sv/yr) and collective doses (manSv/yr) from routine releases of tritium and activation products,** normal operation conditions, 1.0 E+09 Bq released per year, release height 150 m, individual dose to the MEI at 1 km, collective dose between 1km and 100 km, 250 people / km^2

4.4 Dose assessment for realistic source terms under normal operation conditions

Tables 12 and 13 show the dose values for individual source terms of the two different plant designs APM and RPM. Additionally the nuclide which contributes most to the dose is indicated. Later these individual source terms will be combined to a real source term, dependent on the materials chosen for the realization of the plant. As proposed in /FOR94b/ and following the abbreviations from chapter 4.2 of this report, the following combination of individual source terms are possible (tritium is treated separately).

- For the reference plant model:
  1. COOL-RPM + NIT-RPM + BER-RPM
  2. COOL-RPM + ARG-RPM + BER-RPM
  3. COOL-RPM + NIT-RPM + TUN-RPM
  4. COOL-RPM + ARG-RPM + TUN-RPM
- For the alternative plant model:
  5. LA12-APM + COPD-APM + NIT-APM + BER-APM
  6. LA12-APM + COPD-APM + ARG-APM + BER-APM
  7. LA12-APM + COPD-APM + NIT-APM + TUN-APM
  8. LA12-APM + COPD-APM + ARG-APM + TUN-APM

source term	CL (%)	GR (%)	IH (%)	IG (%)	IHR (%)	EDE (Sv/yr)	most important nuclide (% of total)
ARG-APM	99.21	0.00	0.00	0.78	0.00	1.58E-11	Ar-41 (99)
BER-APM	0.15	51.25	2.22	45.13	1.25	9.42E-13	Co-60 (41)
LA12-APM	0.06	25.38	1.08	73.20	0.28	5.36E-07	Ta-182 (59)
COPD-APM	0.08	73.79	3.00	22.27	0.86	4.34E-08	Co-60 (88)
NIT-APM	0.00	0.00	62.27	19.22	18.51	8.21E-14	C-14 (89)
TUN-APM	0.09	4.52	1.38	93.94	0.08	1.32E-09	Ta-182 (63)
T-APM	0.00	0.00	16.50	80.40	3.10	2.74E-07	HTO (100)
ARG-RPM	99.14	0.00	0.00	0.86	0.00	7.77E-11	Ar-41 (99)
BER-RPM	0.25	51.23	2.58	45.76	0.18	5.95E-13	Co-60 (23)
COOL-RPM	22.27	40.69	7.90	29.07	0.07	2.55E-11	Sc-48 (79)
NIT-RPM	9.86	0.45	55.58	17.72	16.39	4.45E-13	C-14 (79)
TUN-RPM	0.02	5.69	0.40	93.82	0.07	1.05E-09	Ta-182 (70)
T-RPM	0.00	0.00	16.50	80.40	3.10	2.72E-07	HTO (100)

Table 12: **Individual effective dose (EDE) of the MEI at 1 km distance**, routine release scenarios for alternative and reference plant model, stack release (150 m)

source term	CL (%)	GR (%)	IH (%)	IG (%)	IHR (%)	CEDE (manSv/yr)	most important nuclide (% of total dose)
ARG-APM	99.17	0.00	0.00	0.82	0.00	5.33E-07	Ar-41 (99)
BER-APM	0.23	44.80	6.01	46.79	2.17	5.23E-08	HTO (39)
LA12-APM	0.10	29.40	3.34	66.86	0.34	2.05E-02	Ta-182 (55)
COPD-APM	0.16	73.28	8.05	17.56	0.95	1.93E-03	Co-60 (86)
NIT-APM	0.00	0.00	82.85	10.68	6.47	7.59E-09	C-14 (91)
TUN-APM	0.26	5.47	4.12	90.08	0.09	4.75E-05	Ta-182 (62)
T-APM	0.00	0.00	20.40	68.13	11.47	2.34E-02	HTO (100)
ARG-RPM	99.10	0.00	0.00	0.90	0.00	2.63E-06	Ar-41 (99)
BER-RPM	0.40	47.42	5.67	44.81	1.70	2.84E-08	HTO (29)
COOL-RPM	12.73	43.42	19.12	24.66	0.08	9.49E-07	Sc-48 (98)
NIT-RPM	0.39	0.01	80.09	11.27	8.24	3.59E-08	C-14 (90)
TUN-RPM	0.05	7.07	1.34	91.48	0.09	3.76E-05	Ta-182 (70)
T-RPM	0.00	0.00	20.40	68.13	11.47	2.33E-02	HTO (100)

Table 13: **Collective effective dose (CEDE) of the public between 1 to 100 km,** routine release scenarios for alternative and reference plant model, stack release (150 m), uniform population distribution, 250 people per square kilometer

The EDE and the collective dose of the 11 materials as well as the 8 possible combinations + tritium are presented in Tables 12 to 14. Table 14 includes also the most important individual material of the combined source term together with its contribution to the total dose. The higest does result from tritium for both plant designs. Beneth tritium, the most critical material for the RPM seems to be the tungsten which covers the first wall, whereas for the APM the material chosen for the cooling loops, the special LA12TaLC steel, is the most radiotoxic one. For the activation products, the dose values resulting from releases from the APM are considerably higher than from the RPM. However, the tritium releases equal the dose for both.

combined source terms	EDE (Sv/yr)	most important individual material (%)	CEDE (manSv/yr)	most important individual material (%)
COOL + NIT + BER (RPM)	2.65E-11	COOL (98)	1.01E-06	COOL (94)
COOL + ARG + BER (RPM)	1.04E-10	ARG (75)	3.61E-06	ARG (73)
COOL + NIT + TUN (RPM)	1.08E-09	TUN (97)	3.86E-05	TUN (97)
COOL + ARG + TUN (RPM)	1.15E-09	TUN (91)	4.12E-05	TUN (90)
T (RPM)	2.72E-07	HTO (100)	2.34E-02	HTO (100)
LA12 + COPD + NIT + BER (APM)	5.80E-07	LA12 (92)	2.24E-02	LA12 (92)
LA12 + COPD + ARG + BER (APM)	5.80E-07	LA12 (92)	2.24E-02	LA12 (92)
LA12 + COPD + NIT + TUN (APM)	5.81E-07	LA12 (92)	2.25E-02	LA12 (92)
LA12 + COPD + ARG + TUN (APM)	5.81E-07	LA12 (92)	2.25E-02	LA12 (92)
T (APM)	2.74E-07	HTO (100)	2.33E-02	HTO (100)

Table 14: Combination of possible source terms for alternative and reference plant models, EDE and CEDE together with the most important contribution from an individual material

5. Study of the influence on the dose of the release duration

5.1 Theoretical approach

For the characterisation of the prevailing meteorological conditions, mean values, averaged over the release time, are applied in the computer codes for atmospheric dispersion calculations. These mean values depend on the integration period. Assuming different release durations, several episodes of the atmospheric dispersion conditions may be relevant. Firstly, the mean wind direction and secondly, the mean wind speed may change with time. With an increased sampling or release time the peak concentration at a certain distance will be in general reduced due to increased lateral dilution caused by the fluctuations in wind directions. Theoretical work as well as data from observations indicate that with an increased sampling or release time the peak concentration at a certain distance will be in general reduced. The following dependence exists /HIN68/:

$$C_l = C_s \left(\frac{t_l}{t_s} \right)^{-\alpha}$$

in which

C_l = concentration averaged over longer sampling time t_l
C_s = concentration averaged over shorter sampling time t_s
α = exponent of power law

At least two time intervals with different values of α have to be distinguished.

For sampling (release) times less than several hours a value for α ranging from about 0.2 to 0.5 have been recommended by several authors(e.g. see /HIN68/). The authors of /FER80/ support a value of 0.33 for smooth terrain and of 0.25 for sites located in valleys. The work from /WIP61/ leads to the conclusion that a value of 0.2 for α is valid over the whole time interval ranging from some minutes up to several days.

For sampling (release) times longer than several hours up to several days, the application of the formula mentioned above seems to be inappropriate, because the influence of changing atmospheric stabilities has to be taken into account too.

The following short discussion is based on an initial release duration of 1 hour. Two different prevailing atmospheric conditions for the 1 hour release have been investigated, one assuming very high atmospheric turbulence and one assuming very low atmospheric turbulence, the latter often referred as worst case release scenario. If the release occurs in the middle of the day with an unstable atmospheric stratification - increased turbulence - the dilution and spread of the plume is very high. If the same amount of material is released for a period of one day (24 hours), the meteorological conditions will change significantly, especially during the night hours. Under these conditions, stable atmospheric stratification with a reduced turbulence will decrease the plume spreading and increase the time integrated concentration of the radionuclide. In this case a very low value for α might be recommended.

name	stability class	dispersion parameter set	wind speed at 10 m height	precipitation
night	F	Mol	0.5 m/s	no rain
W2791	E	Mol	0.5 m/s	no rain
W4826	E	Mol	0.5 m/s	1.3 mm/hr (1 hour)
unstable	A	Mol	1.5 m/s	no rain

Table 15: Basic meteorological conditions of the first hour for 4 accidental release scenarios

On the other hand if the initial release situation is linked with a stable stratification of the atmosphere, an elongation over the day will reduce the peak concentration not only by changing wind directions but also by the occurrence of an increased number of hours with an unstable atmospheric stratification during the daytime. This case requires now higher values for α ranging from 0.5 up to 0.6 (see /GYL80/).However, one has to be very careful when using such a simple formula.

5.2 Case study

The duration of the releases was varied from 1 to 168 hours with intervals of 6, 24, and 72 hours. The amount of released material was identical for all scenarios. Four different weather sequences were used for the calculations (see Table 15 and also Appendix B). Source term 1 (Beryllium) with the release height of 10 m, including building wake effects, was applied. The EDE at 1 km as well as the collective dose between 1 and 100 km distance were calculated. The ratios of the dose values to those calculated for the one hour release in the first hour were presented in Tables 16 and 17. The sigma parameter set Mol (valid for a one hour release) was applied. A release lasting longer than 1 hour was divided into a multiple of release phases of 1 hour.

Assuming worst case weather conditions (low turbulence in the cases 1 to 3), the EDE at 1 km distance decreases with increasing release time (Table 16). Only for the night case the reduction is rather low for the 6 hours releases, but one has to have in mind that the first 5 hours contain nearly identical meteorological data. Assuming the opposite weather conditions (case 4, unstable conditions in the first hour with a high turbulence und thus a good dilution), the EDE remains nearly constant when prolonging the release time up to 7 days. The collective dose increased with a prolonged release duration, only in the case rain in the first hour, it decreased.

weather sequence	1 hr	6 hrs	24 hrs	72 hrs	168 hrs
morning (W2791)	1.0	0.17	0.11	0.07	0.03
night	1.0	0.93	0.27	0.10	0.06
rain (W4821)	1.0	0.17	0.04	0.02	0.01
unstable	1.0	0.80	2.10	1.60	0.70

Table 16: **Ratio of the EDE at 1 km compared to the dose value of the one hour release.** (release duration of 1, 6, 24, 72 and 168 hours with identical total amount of released material, source term 1 (Beryllium), release height 10 m, with building wake effects)

weather sequence	1 hr	6 hrs	24 hrs	72 hrs	168 hrs
morning (2791)	1.0	0.90	1.10	1.82	1.45
night	1.0	0.90	0.60	0.85	1.20
rain (W4821)	1.0	0.74	0.28	0.15	0.17
unstable	1.0	1.04	1.83	2.44	1.95

Table 17: **Ratio of the collective dose between 1 and 100 km compared to the dose value of the one hour release** (release duration of 1, 6, 24, 72 and 168 hours with identical total amount of released material, source term 1 (Beryllium), release height 10 m, with building wake effects, 250 people / km^2),

The following conclusions may be drawn from the results obtained:

- The application of the sampling (release) time formula is possible if the release time is in the order of several hours and the meteorological conditions (especially the atmospheric stability) do not change considerably
- If the formula is used for longer release (sampling) times the initial weather conditions will become very important.
- **Initial stable conditions**: evident decrease of the dose with increasing release (sampling) time (α may be set to a value of about 0.5).

- o **Initial unstable conditions**: the dose may slightly decrease with increasing release (sampling) time and α has very low values (0.2 or less); or in some cases, the dose will increase with prolonged release (sampling) time and the formula can **not** be applied.

6. Special Investigations about mobilisation source terms

Calculations with mobilisation source terms have been performed for tritium and activation products such as erosion dust and coolant activation for both the RPM and the APM. The accident was assumed to be an in-vessel LOCA. Three release scenarios have been investigated:

1. It was assumed that the second and third barrier remains intact and the leakage was set to 1 vol% per day at 1 hPa pressure difference. There is no filtering for activation products and tritium.
2. It was assumed that the second barrier is damaged and the third remains still intact. A rather high emission is going on through the second to the third barrier what causes the all activity leaving the area between the second and third barrier via the stack. The stack filter efficiency for aerosols is 99%. There is no tritium filtering.
3. Again it was assumed that the second barrier is damaged and the third remains still intact. The normal venting continues and all the activity leaves the area between the second and third barrier via the stack. The stack filter efficiency for aerosols is 99%. The filter factor for HTO is 99.95%. HT is filtered by oxidation into HTO with an efficiency of 99.95%. The converted HTO is filtered again with an efficieny of 99.95%.

RPM source terms

Two basic source terms have been assumed for the RPM. They result from different armour materials of the first wall which are either beryllium or tungsten. Both materials contain some tritium which is considered in the calculations. Additionally, 1.0 kg of tritium in HT form is mobilised too. As the behaviour of tritium in the plant is still under discussion, the mobilisation rate was linked simply to the proposed behaviour of the helium gas in the plant. This includes the assumption of a constant release rate into the environment. The release fractions are provided by /FOR94c/. Therefrom the following source release scenarios are defined for the RPM:

1) Scenario 1 with ground level release, no aerosol filtering, no detritiation filtering
   initial 0.7 kg beryllium with tritium as HT
   initial 6.0 kg of tungsten with tritium as HT
   initial 1.0 kg of tritium as HT
2) Scenario 2 with stack release and high venting, aerosol filtering, no detritiation filtering
   initial 6.0 kg of tungsten with tritium as HT
   initial 0.7 kg of beryllium with tritium as HT
   initial 1.0 kg of tritium as HT
3) Scenario 3 with stack release and normal venting, aerosol filtering, detritiation filtering
   initial 6.0 kg of tungsten with tritium as HT
   initial 0.7 kg of beryllium with tritium as HT
   initial 1.0 kg of tritium as HT

The weather sequence W4826 was used for the calculations. As before, the basic release height was set to 10 m and the building wake effects are included. For the stack scenario the release height was set to 150 m. The source terms was subdivided into 60 phases of one hour duration. The released material with starting points later than 60 phases was added to the individual release fractions. For case one and two the release duration was set to 60 hours which means that 60 phases follow each other consecutively. The release duration for case three was 10 times longer which was modelled as a delay of 10 hours between each release phase of one hour. The activity released within one phase of one hour duration is the summed activity over 10 hours. The total release duration was 600 hours. The mobilisation calculations were documented elsewhere /BUN94/. Some additional results of the dose assessments are presented in Appendix C. A summary can be found in the following tables.

case name	EDE (Sv)	important nuclide (% of total)	CEDE (manSv)	important nuclide (% of total)
Be-HT	4.0 E-08	Co-60 (31)	7.8 E-05	Co-60 (31)
Tu-HT	9.2 E-04	Ta-182 (70)	1.8	Ta-182 (70)
HT	1.1 E-05	HTO (100)	3.8 E-02	HTO (100)

Table 18: EDE from mobilisation source term 1 (ground level release) for the RPM, weather sequence W4826, release duration 60 hours, release fractions from /BUN94, FOR94c/

case name	early dose (Sv)	important nuclide (% of total)
Be-HT	2.6 E-09	Co-58 (24)
Tu-HT	1.3 E-05	Ta-182 (57)
HT	1.5 E-07	HTO (99)

Table 19. Early dose from mobilisation source term 1 for the RPM, weather sequence W4826, release duration 60 hours, release fractions from /BUN94, FOR94c/

case name	EDE (Sv)	important nuclide (% of total)	CEDE (manSv)	important nuclide (% of total)
Be-HT	3.7 E-08	Co-60 (29)	1.1 E-04	HTO (59)
Tu-HT	9.2 E-04	Ta-182 (70)	1.9	Ta-182 (70)
HT	2.7 E-05	HTO (100)	0.7	HTO (100)

Table 20: EDE from mobilisation source term 2 (stack with high venting) for the RPM, weather sequence W4826, release duration 60 hours, release fractions from /BUN94, FOR94c/

case name	early dose (Sv)	important nuclide (% of total)
Be-HT	7.5 E-10	Na-24 (33)
Tu-HT	2.5 E-06	Ta-182 (44)
HT	1.7 E-07	HTO (100)

Table 21: **Early dose from mobilisation source terms for the RPM case 2,** weather sequence W4826, release duration 60 hours, release fractions from /BUN94, FOR94c/

case name	EDE (Sv)	important nuclide (% of total)	CEDE (manSv)	important nuclide (% of total)
Be-HT	2.5 E-09	Co-60 (30)	6.2 E-06	Co-60 (31)
Tu-HT	5.9 E-05	Ta-182 (70)	9.9 E-02	Ta-182 (70)
HT	3.1 E-07	HTO (100)	1.5 E-02	HTO (100)

Table 22: **EDE from mobilisation source term 3 (stack with normal venting) for the RPM,** weather sequence W4826, release duration 600 hours, release fractions from /BUN94, FOR94c/

case name	early dose (Sv)	important nuclide (% of total)
Be-HT	1.5 E-10	Na-24 (28)
Tu-HT	1.6 E-07	Ta-182 (44)
HT	1.7 E-08	HTO (100)

Table 23: **Early dose from mobilisation source terms for the RPM case 3,** weather sequence W4826, release duration 600 hours, release fractions from /BUN94, FOR94c/

The Tables 18, 20 and 22 show, that the beryllium source terms result in rather low effective doses. The doses from the tungsten are considerably higher and are dominated by Ta-182. Adding by the 1.0 kg of tritium will dominate the total dose for the Be-source term but not for the Tu-source term. In case of filtering for both the activation products and tritium (scenario 3) the doses are very low. Without any filter factor applied, scenario 1 shows the highest doses. However, scenario 2 with a filter efficency of 99% for the aerosols results in a similar dose value caused by the increased amount of released material (50 times more material with a peak release in the first hour).

The early dose which is identical to the intervention dose for evacuation, is defined as the result from the first week external exposure and a 50 years integration time for inhalation. The exposure pathways are the external irradiation from the passing cloud, the external irradiation from the ground surface, the internal irradiation from inhalation (+ skin absorption for tritium) from the passing cloud and the internal irradiation from inhalation (+ skin absorption for tritium) from the reemitted activity; the ingestion pathways are not considered. The early doses for the RPM are presented in Tables 19, 21 and 23. It is obvious that the evacuation criteria of 100 mSv which has been selected in the SEAFP study is not exceeded.

APM source terms

Similar dose assessments were performed for the APM. Four cases, two divertor LOCAs and two primary coolant LOCAs were investigated /BUN94/. The release scenarios were identical to the three reported for the RPM. As for the RPM, the behaviour of tritium in the plant is still under discussion and the mobilisation rate was linked simply to the proposed behaviour of helium. This includes the assumption of a constant release rate into the environment. The release fractions were provided by /FOR94c/.The three release scenarios for the APM contain 5 cases and can be characterised as:

1) Scenario 1 with ground level release, no aerosol filtering, no detritiation filtering
   Divertor LOCA with Be-armour and copper structure (APM11)
   Primary coolant LOCA with Be-armour and La-steel structure (APM12)
   Divertor LOCA with W-armour and copper structure (APM21)
   Primary coolant LOCA with W-armour and La-steel structure (APM22)
   1 kg of tritium as HTO (HTO1)
2) Scenario 2 with stack release and high venting, aerosol filtering, no detritiation filtering
   Divertor LOCA with Be-armour and copper structure (APM11-2)
   Primary coolant LOCA with Be-armour and La-steel structure (APM12-2)
   Divertor LOCA with W-armour and copper structure (APM21-2)
   Primary coolant LOCA with W-armour and La-steel structure (APM22-2
   1 kg of tritium as HTO (HTO2)
3) Scenario 3 with stack release and normal venting, aerosol filtering, detritiation filtering
   Divertor LOCA with Be-armour and copper structure (APM11-3)
   Primary coolant LOCA with Be-armour and La-steel structure (APM12-3)
   Divertor LOCA with W-armour and copper structure (APM21-3)
   Primary coolant LOCA with W-armour and La-steel structure (APM22-3
   1 kg of tritium as HTO (HTO3)

Again, the weather sequence W4826 was used for the calculations. As before, the basic release height was set to 10 m and the building wake effects were included. The source terms were subdivided into 60 phases of 1 hour duration. The released material with starting times later than 60 phases was added to the individual release fractions. For case one and two the release duration was 60 hours which means that the 60 phases follow each other consecutively.The release duration for case three was 5 times longer which was modelled as a delay of 10 hours between each phase. The activity released within one phase of one hour duration is the summed activity over 5 hours. The total release duration was 300 hours. As for the RPM, the mobilisation calculations were documented elsewhere /BUN94/. Some additional results of the dose assessments are presented in Appendix C. A summary can be found in the following tables.

case name	EDE (Sv)	important nuclide (% of total)	CEDE (manSv)	important nuclide (% of total)
APM11	1.8 E-03	Co-60 (92)	3.6	Co-60 (92)
APM12	3.9E-03	Ta-182 (57)	4.5	Ta-182 (57)
APM21	3.4 E-03	Co-60 (48)	6.6	Co-60 (48)
APM22	4.3 E-03	Ta-182 (57)	4.9	Ta-182 (57)
HTO1	3.2 E-04	HTO (100)	1.2	HTO (100)

Table 24: **Dose from mobilisation source term 1 (ground level release) for the APM,** weather sequence W4826, release duration 60 hours, release fractions from /BUN94, FOR94c/

case name	early dose (Sv)	important nuclide (% of total)
APM11	6.1 E-05	Co-60 (94)
APM12	1.2 E-04	Mn-54 (47)
APM21	2.4 E-04	Co-60 (46)
APM22	4.4 E-05	Mn-54 (42)
HTO1	4.2 E-05	HTO (100)

Table 25: **Early dose from mobilisation source term 1 (ground level release) for the APM,** weather sequence W4826, release duration 60 hours, release fractions from /BUN94, FOR94c/

case name	EDE (Sv)	important nuclide (% of total)	CEDE (manSv)	important nuclide (% of total)
APM11-2	1.1 E-02	Co-60 (92)	10.6	Co-60 (92)
APM12-2	3.6 E-02	Ta-182 (57)	26.6	Ta-182 (57)
APM21-2	2.1 E-02	Co-60 (48)	20.1	Co-60 (48)
APM22-2	3.9 E-02	Ta-182 (57)	28.4	Ta-182 (56)
HTO2	9.0 E-04	HTO (100)	16.8	HTO (100)

Table 26: **Dose from mobilisation source term 2 (stack with high venting) for the APM,** weather sequence W4826, release duration 60 hours, release fractions from /BUN94, FOR94c/

case name	early dose (Sv)	important nuclide (% of total)
APM11-2	4.4 E-05	Co-60 (84)
APM12-2	1.7 E-04	Mn-54 (75)
APM21-2	1.1 E-04	Co-60 (35)
APM22-2	1.9 E-04	Mn-54 (68)
HTO2	6.5 E-05	HTO (100)

Table 27: Early dose from mobilisation source term 2 (stack with high venting) for the APM, weather sequence W4826, release duration 60 hours, release fractions from /BUN94, FOR94c/

case name	EDE (Sv)	important nuclide (% of total)	CEDE (manSv)	important nuclide (% of total)
APM11-3	2.4 E-05	Co-60 (95)	6.0 E-02	Co-60 (95)
APM12-3	5.7 E-05	Ta-182 (39)	8.5 E-02	Ta-182 (39)
APM21-3	1.3 E-04	Ta-182 (53)	3.2 E-01	Ta-182 (53)
APM22-3	6.0 E-05	Ta-182 (55)	8.9 E-02	Ta-182 (55)
HTO3	3.6 E-07	HTO (100)	1.9 E-02	HTO (100)

Table 28: Dose from mobilisation source term 3 (stack with normal venting) for the APM, weather sequence W4826, release duration 300 hours, release fractions from /BUN94, FOR94c/

case name	early dose (Sv)	important nuclide (% of total)
APM11-3	9.6 E-08	Co-60 (95)
APM12-3	2.7 E-07	Mn-54 (51)
APM21-3	6.6 E-07	W-187 (43)
APM22-3	2.9 E-07	Mn-54 (48)
HTO3	1.5 E-08	HTO (100)

Table 29: Early dose from mobilisation source term 3 (stack with normal venting) for the APM, weather sequence W4826, release duration 300 hours, release fractions from /BUN94, FOR94c/

The doses from the APM are dominated by the activation product source terms (Tables 24, 25 and 26). The EDEs from the case 2 are higher than those from the ground level release. This result may look a little bit strange in the first moment but is caused by the fact that the reduction processes of filtering is nearly compensated by the higher amount of released material. Additionally, the highly non-linear release pattern with a peak in the first hour - the worst case hour - is the reason for the relatively high dose values. The scenario 3 with all the filter systems working show the lowest doses for the APM. The early doses are considerably lower than the intervention level for all APM cases (Table 25, 26 and 28).

Until now, the problem of food banning is not considered in all the previous dose assessments. As the question of food banning cannot be answered for the activation products due to missing concentration values in the foodstuffs, an assessment has been performed only for tritium without detritiation filtering (30). Due to the small amount of released tritium for the present source terms of the RPM and APM plant model, food banning may occur only in the first year. However, a banning area of about 200 km^2 for one year duration is not negligibly small. Additionally, larger areas may be affected by banning of other foodstuffs, but the ban duration is rather short (milk in the first month). As soon as the database of COSYMA is improved and allows for considering activity concentrations in foodstuffs, new calculations are strongly recommended.

case name	**Area of foodbans in the first year (km^2)**	**foodstuffs which cause the ban**	**Area of foodbans in the second year (km^2)**
HT, RPM-1	5	milk (7 days)	0.0
HT, RPM-2	10	wheat	0.0
HT, RPM-3	-	-	0.0
HTO, APM-1	45	wheat	0.0
HTO, APM-2	220	wheat	0.0
HTO, APM-3	-	-	0.0

Table 30: Area and time duration of foodbans from mobilisation source terms, weather sequence W4826, release of 1 kg tritium, release fractions from /FOR94c/, ban criteria: tritium conc. > 1250 Bq/kg fresh weight

From the calculations performed and discussed, it can be concluded, that no emergency action is necessary as the early doses are far below the intervention doses and the EDEs are rather low. However, it remains the necessity to investigate in more detail the behaviour of tritium in the plant itself. Another point to mention is the weather sequence selected for the mobilisation calculations. The starting point is identical to the weather sequence W4826, which is a worst case sequence in the first hour. However the remaining 59 phases may not necessarily represent a worst case for a prolonged release. Thus it seems to be necessary to repeat some of the calculations for different meteorological conditions. Nevertheless it seems to be possible to estimate the possible range in the dose values by expert judgement as well as when comparing the results from chapter 5. What has not been presented in chapter 5 is the fact that the dose values from the same amount of activity released over a period of 3 days in comparison to one hour show differences of about a factor of 2 - 3 instead of about one order of magnitude. Thus, the potential range of uncertainty seems to be rather low. On the other hand it has been demonstrated that for the scenario 2 with the high release in the beginning, the W4826 is really a worst case scenario. A last point to mention is the assessment accuracy of the ingestion pathways. For the calculations a simplified ingestion model has been used, which gives in general a conservative assessment of the expected dose value. For this reason, calculations with state of the art foodchain models are under way to close this gap in the data base of COSYMA. If these data are available a revision of the dose calculations will be performed on request.

7. Special investigations about weather conditions which cause the highest EDE at the fence from stack releases

Four nuclides with different important exposure pathways have been selected for this investigation:

1) Be-10: pathway inhalation most important one
2) Ar-41: pathway plume irradiation most important one
3) C0-60: pathways irradiation from ground and ingestion most important ones
4) HTO: pathway ingestion most important one

The parameters for the computer runs are listed below:

stack release of 150m
constant wind direction and wind speed (0.5 m/s at 10m height), no rain
stability class ranging from very unstable (A) to very stable (F)
sigma values from MOL
release of 1.0e+09 Bq

Be-10	A	B	C	D	E	F
680	**4.1 E-7**	**3.1 E-7**	1.8 E-7	4.2 E-8		
1000	2.9 E-7	2.9 E-7	**2.5 E-7**	1.2 E-7	2.6 E-8	4.8 E-9
1500	1.9 E-7	2.1 E-7	2.3 E-7	**1.8 E-7**	8.7 E-8	4.1 E-8
2000	1.2 E-7	1.6 E-7	1.9 E-7	1.8 E-7	1.2 E-7	8.7 E-8
3200					**1.3 E-7**	**1.4 E-7**

Table 23: Maximum EDE (Sv) of the MEI at various distances from stack releases (Be-10), release height 150m, various stability classes

Ar-41	A	B	C	D	E	F
680	**4.5 E-10**	**4.1 E-10**	**3.9 E-10**	**3.0E-10**		
1000	3.6 E-10	2.9 E-10	3.3 E-10	2.7 E-10	**2.1 E-10**	**2.1 E-10**
1500	2.3 E-10	2.3 E-10	2.4 E-10	2.3 E-10	2.0 E-10	2.1 E-10
2000	1.5 E-10	1.8 E-10	2.1 E-10	2.0 E-10	1.9 E-10	2.0 E-10
3200					1.3 E-10	1.6 E-10

Table 24: Maximum EDE (Sv) of the MEI at various distances from stack releases (Ar-41), release height 150m, various stability classes

Co-60	A	B	C	D	E	F
680	**3.0 E-6**	**2.8 E-6**	1.6 E-6	3.7 E-7		
1000	2.6 E-6	2.6 E-6	**2.2 E-6**	1.1 E-6	2.3 E-7	4.4 E-8
1500	1.7 E-6	1.9 E-6	2.1 E-6	1.6 E-6	7.8 E-7	3.7 E-7
2000	1.1 E-6	1.4 E-6	1.7 E-6	**1.7 E-6**	1.1 E-6	7.8 E-7
3200					**1.2 E-6**	**1.2 E-6**

Table 25: Maximum EDE (Sv) of the MEI at various distances from stack releases (Co-60), release height 150m, various stability classes

HTO	A	B	C	D	E	F
680	**6.67 E-10**	**4.98 E-10**	2.90 E-10	7.29 E-11		
1000	4.74 E-10	4.43 E-10	**3.80 E-10**	1.89 E-10	4.34 E-12	2.02 E-13
1500	3.04 E-10	3,21 E-10	3.47 E-10	**2.60 E-10**	4.18 E-11	8.12 E-12
2000	2.06 E-10	2.44 E-10	2.89 E-10	2.57 E-10	1.25 E-10	5.75 E-11
3200					**1.72 E-10**	**1.13 E-10**

Table 26: Maximum EDE (Sv) of the MEI at various distances from stack releases (HTO), release height 150m, various stability classes

Aerosols (case 1, 3 and 4) and noble gases (2) show a different behaviour due to the varying relevance of the exposure pathways. If the dose is dominated by ground contamination related exposure pathways or by inhalation, the unstable weather conditions (class A to C) give the highest EDEs up to 1 km distance. Under neutral or stable atmospheric stratification, the maximum dose is obtained at farther distances, up to several kilometers from the source for the very stable conditions (F). This behaviour differs only in the case of the noble gas because the exposure pathway irradiation from the cloud is the dominating one.

One can draw the conclusion, that the worst case conditions for stack releases without rain are related to unstable weather conditions. However, in case of rain the doses are always higher than for dry deposition only (see results in chapter 3, Table 3 and 4).

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Appendix A

Dose results

Dose results from accidental releases

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	EDE (SV)
HT	0.00	0.00	0.01	99.71	0.28	4.24E-10
HTO	0.00	0.00	19.21	80.63	0.16	6.38E-09
BE- 10	0.00	0.30	75.55	19.70	4.45	6.14E-06
C - 14	0.00	0.00	1.48	98.44	0.09	1.89E-06
N - 13	89.55	2.37	8.05	0.03	0.00	3.49E-10
N - 16	99.84	0.02	0.15	0.00	0.00	3.97E-43
AR- 39	100.00	0.00	0.00	0.00	0.00	3.60E-13
AR- 41	100.00	0.00	0.00	0.00	0.00	3.40E-09
AR- 42	3.64	5.78	56.27	34.27	0.04	8.03E-10
CA- 45	0.00	0.00	3.78	96.05	0.17	2.11E-06
CA- 47	0.40	4.96	7.73	86.87	0.04	9.65E-07
SC- 46	0.14	39.51	6.49	53.63	0.24	4.23E-06
SC- 47	0.61	8.31	38.06	52.88	0.15	6.03E-08
SC- 48	5.91	33.37	28.12	32.54	0.06	1.74E-07
TI- 51	80.44	1.26	18.27	0.03	0.00	2.66E-11
CR- 51	0.19	32.17	6.51	60.98	0.14	4.70E-08
MN- 54	0.06	81.18	1.86	16.80	0.09	4.24E-06
MN- 56	44.23	20.47	30.91	4.39	0.00	1.04E-08
FE- 55	0.00	0.00	4.55	95.19	0.25	3.59E-07
FE- 59	0.13	25.20	5.01	69.52	0.14	2.94E-06
CO- 60	0.01	73.94	5.08	20.67	0.29	5.50E-05
NI- 59	0.00	0.01	8.33	91.17	0.49	1.42E-07
NI- 63	0.00	0.00	7.89	91.64	0.46	3.71E-07
CU- 64	8.94	17.92	43.78	29.32	0.03	6.97E-09
TA-182	0.01	3.72	1.23	94.99	0.05	4.01E-05
W -187	5.19	19.71	30.67	44.40	0.04	2.72E-08
RE-186	0.06	1.06	35.64	63.09	0.15	1.18E-07
RE-188	0.42	1.17	57.01	41.36	0.05	4.28E-08
HG-203	0.00	0.48	0.27	99.23	0.01	2.92E-05
PB-203	3.42	30.03	20.65	45.84	0.05	2.45E-08
PO-210	0.00	0.00	19.65	79.50	0.86	5.59E-04

Table A1: EDE (Sv) of the MEI at 1 km distance from accidentally released activation products (weather sequence W2791B, 10 m release height), unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 hour

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	CEDE (MANSV)
HT	0.00	0.00	0.01	95.00	4.99	1.80E-07
HTO	0.00	0.00	5.29	89.92	4.79	3.02E-06
BE- 10	0.00	0.30	75.55	19.70	4.45	9.59E-04
C - 14	0.00	0.00	1.48	98.44	0.09	2.96E-04
N - 13	93.87	1.39	4.72	0.02	0.00	1.37E-08
N - 16	99.94	0.01	0.05	0.00	0.00	1.79E-40
AR- 39	100.00	0.00	0.00	0.00	0.00	1.75E-10
AR- 41	100.00	0.00	0.00	0.00	0.00	5.76E-07
AR- 42	10.34	5.38	52.36	31.89	0.03	1.24E-06
CA- 45	0.00	0.00	3.78	96.05	0.17	3.29E-04
CA- 47	1.15	4.93	7.67	86.21	0.04	1.46E-04
SC- 46	0.40	39.40	6.47	53.49	0.24	6.61E-04
SC- 47	1.74	8.21	37.63	52.28	0.15	9.50E-06
SC- 48	15.32	30.04	25.31	29.29	0.05	2.76E-05
TI- 51	87.44	0.81	11.73	0.02	0.00	7.70E-10
CR- 51	0.56	32.05	6.49	60.76	0.14	7.32E-06
MN- 54	0.18	81.09	1.86	16.78	0.09	6.63E-04
MN- 56	67.23	12.03	18.17	2.58	0.00	1.23E-06
FE- 55	0.00	0.00	4.55	95.19	0.25	5.61E-05
FE- 59	0.37	25.14	5.00	69.35	0.14	4.59E-04
CO- 60	0.04	73.93	5.08	20.66	0.29	8.60E-03
NI- 59	0.00	0.01	8.33	91.17	0.49	2.22E-05
NI- 63	0.00	0.00	7.89	91.64	0.46	5.79E-05
CU- 64	21.79	15.39	37.60	25.19	0.02	9.67E-07
TA-182	0.03	3.72	1.23	94.97	0.05	6.25E-03
W -187	13.56	17.97	27.96	40.48	0.03	3.98E-06
RE-186	0.18	1.06	35.60	63.01	0.15	1.76E-05
RE-188	1.18	1.16	56.57	41.04	0.05	5.45E-06
HG-203	0.01	0.48	0.27	99.23	0.01	4.54E-03
PB-203	9.27	28.22	19.40	43.06	0.05	3.77E-06
PO-210	0.00	0.00	19.65	79.50	0.86	8.71E-02

Table A2: **Collective CEDE (manSv) between 1 km to 100 km distance from accidentally released activation products (weather sequence W2791B, 10 m release height),** unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 hour, population density of 250 people per square kilometer

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	EDE (SV)
HT	0.00	0.00	0.01	98.12	1.87	6.60E-13
HTO	0.00	0.00	15.37	82.95	1.68	1.03E-11
BE- 10	0.00	0.30	75.55	19.70	4.45	4.85E-09
C - 14	0.00	0.00	1.48	98.44	0.09	1.50E-09
N - 13	99.83	0.04	0.13	0.00	0.00	8.68E-11
N - 16	100.00	0.00	0.00	0.00	0.00	2.65E-35
AR- 39	100.00	0.00	0.00	0.00	0.00	1.90E-14
AR- 41	100.00	0.00	0.00	0.00	0.00	2.08E-10
AR- 42	72.33	1.66	16.16	9.84	0.01	6.67E-13
CA- 45	0.00	0.00	3.78	96.05	0.17	1.67E-09
CA- 47	21.86	3.89	6.07	68.15	0.03	9.74E-10
SC- 46	8.77	36.09	5.93	48.99	0.22	3.66E-09
SC- 47	29.80	5.87	26.88	37.35	0.10	6.75E-11
SC- 48	81.38	6.60	5.56	6.44	0.01	7.00E-10
TI- 51	99.65	0.02	0.33	0.00	0.00	1.91E-11
CR- 51	11.89	28.40	5.75	53.83	0.12	4.21E-11
MN- 54	4.08	77.92	1.79	16.12	0.09	3.49E-09
MN- 56	98.22	0.65	0.99	0.14	0.00	2.90E-10
FE- 55	0.00	0.00	4.55	95.19	0.25	2.84E-10
FE- 59	8.22	23.15	4.61	63.88	0.13	2.53E-09
CO- 60	0.99	73.22	5.03	20.47	0.29	4.39E-08
NI- 59	0.00	0.01	8.33	91.17	0.49	1.12E-10
NI- 63	0.00	0.00	7.89	91.64	0.46	2.93E-10
CU- 64	87.23	2.51	6.14	4.11	0.00	4.01E-11
TA-182	0.67	3.70	1.22	94.36	0.05	3.19E-08
W -187	79.19	4.33	6.73	9.74	0.01	9.91E-11
RE-186	4.06	1.02	34.22	60.56	0.15	9.70E-11
RE-188	22.50	0.91	44.37	32.19	0.04	4.41E-11
HG-203	0.18	0.48	0.27	99.06	0.01	2.31E-08
PB-203	71.14	8.97	6.17	13.70	0.02	6.50E-11
PO-210	0.00	0.00	19.65	79.50	0.86	4.41E-07

Table A3: EDE (Sv) of the MEI at 1 km distance from accidentally released activation products (weather sequence W2791S, 150 m release height), unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 hour

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	CEDE (MANSV)
HT	0.00	0.00	0.01	94.75	5.24	1.03E-07
HTO	0.00	0.00	5.18	90.33	4.49	2.13E-06
BE- 10	0.00	0.30	75.55	19.70	4.45	5.91E-04
C - 14	0.00	0.00	1.48	98.44	0.09	1.82E-04
N - 13	98.13	0.42	1.44	0.00	0.00	1.80E-08
N - 16	100.00	0.00	0.00	0.00	0.00	1.40E-33
AR- 39	100.00	0.00	0.00	0.00	0.00	1.34E-10
AR- 41	100.00	0.00	0.00	0.00	0.00	5.12E-07
AR- 42	11.32	5.32	51.79	31.54	0.03	6.81E-07
CA- 45	0.00	0.00	3.78	96.05	0.17	2.03E-04
CA- 47	1.56	4.91	7.64	85.86	0.04	9.10E-05
SC- 46	0.54	39.35	6.46	53.41	0.24	4.08E-04
SC- 47	2.33	8.16	37.40	51.96	0.15	5.90E-06
SC- 48	19.92	28.40	23.93	27.70	0.05	1.82E-05
TI- 51	97.36	0.17	2.47	0.00	0.00	2.06E-09
CR- 51	0.75	31.99	6.48	60.64	0.14	4.52E-06
MN- 54	0.24	81.04	1.86	16.77	0.09	4.09E-04
MN- 56	78.07	8.05	12.15	1.72	0.00	1.01E-06
FE- 55	0.00	0.00	4.55	95.19	0.25	3.45E-05
FE- 59	0.50	25.10	4.99	69.26	0.14	2.83E-04
CO- 60	0.06	73.91	5.08	20.66	0.29	5.30E-03
NI- 59	0.00	0.01	8.33	91.17	0.49	1.37E-05
NI- 63	0.00	0.00	7.89	91.64	0.46	3.57E-05
CU- 64	28.55	14.06	34.35	23.01	0.02	6.68E-07
TA-182	0.04	3.72	1.23	94.96	0.05	3.85E-03
W -187	17.95	17.06	26.54	38.42	0.03	2.64E-06
RE-186	0.24	1.06	35.58	62.97	0.15	1.09E-05
RE-188	1.66	1.15	56.30	40.85	0.05	3.45E-06
HG-203	0.01	0.48	0.27	99.22	0.01	2.80E-03
PB-203	12.28	27.28	18.76	41.63	0.05	2.43E-06
PO-210	0.00	0.00	19.65	79.50	0.86	5.37E-02

Table A4: **Collective CEDE (manSv) between 1 km to 100 km distance from accidentally released activation products (weather sequence W2791S, 150 m release height),** unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 hour, population density of 250 people per square kilometer

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	EDE (SV)
HT	0.00	0.00	0.01	99.18	0.81	2.73E-10
HTO	0.00	0.00	15.06	83.65	1.29	4.30E-09
BE- 10	0.00	0.88	27.25	58.62	13.25	9.23E-06
C - 14	0.00	0.00	0.18	99.73	0.09	8.36E-06
N - 13	76.74	16.36	6.73	0.18	0.00	2.26E-10
N - 16	99.72	0.14	0.14	0.00	0.00	2.21E-43
AR- 39	100.00	0.00	0.00	0.00	0.00	2.54E-13
AR- 41	100.00	0.00	0.00	0.00	0.00	2.40E-09
AR- 42	0.95	12.20	14.41	72.37	0.08	1.93E-09
CA- 45	0.00	0.00	0.47	99.35	0.18	9.13E-06
CA- 47	0.05	5.34	1.01	93.55	0.04	4.01E-06
SC- 46	0.02	41.95	0.84	56.94	0.26	1.78E-05
SC- 47	0.11	12.58	6.99	80.09	0.22	1.78E-07
SC- 48	1.05	47.60	4.86	46.41	0.09	5.46E-07
TI- 51	74.04	9.34	16.41	0.21	0.00	1.61E-11
CR- 51	0.03	34.18	0.84	64.80	0.15	1.98E-07
MN- 54	0.01	82.58	0.23	17.09	0.10	1.87E-05
MN- 56	16.12	60.03	10.99	12.86	0.01	1.59E-08
FE- 55	0.00	0.00	0.58	99.16	0.26	1.54E-06
FE- 59	0.02	26.39	0.64	72.81	0.15	1.26E-05
CO- 60	0.00	77.41	0.65	21.64	0.30	2.35E-04
NI- 59	0.00	0.01	1.09	98.37	0.53	5.88E-07
NI- 63	0.00	0.00	1.03	98.47	0.50	1.54E-06
CU- 64	2.07	33.38	9.88	54.61	0.05	1.67E-08
TA-182	0.00	3.76	0.15	96.03	0.05	1.77E-04
W -187	0.94	28.77	5.43	64.81	0.05	8.34E-08
RE-186	0.01	1.54	6.30	91.93	0.23	3.61E-07
RE-188	0.10	2.35	13.95	83.49	0.10	9.48E-08
HG-203	0.00	0.48	0.03	99.47	0.01	1.30E-04
PB-203	0.54	38.09	3.18	58.13	0.07	8.62E-08
PO-210	0.00	0.00	2.88	96.09	1.04	2.07E-03

Table A5: **EDE (Sv) of the MEI at 1 km distance from accidentally released activation products (weather sequence W4826B, 10 m release height),** unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 hour

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	CEDE (MANSV)
HT	0.00	0.00	0.01	94.99	5.00	1.61E-07
HTO	0.00	0.00	2.11	91.33	6.56	3.41E-06
BE- 10	0.00	0.95	21.26	63.45	14.34	1.60E-03
C - 14	0.00	0.00	0.13	99.78	0.09	1.56E-03
N - 13	81.87	13.14	4.85	0.14	0.00	7.08E-09
N - 16	99.86	0.08	0.06	0.00	0.00	7.15E-41
AR- 39	100.00	0.00	0.00	0.00	0.00	1.87E-10
AR- 41	100.00	0.00	0.00	0.00	0.00	5.97E-07
AR- 42	2.47	12.22	12.76	72.47	0.08	2.53E-06
CA- 45	0.00	0.00	0.34	99.48	0.18	1.70E-03
CA- 47	0.09	5.36	0.73	93.78	0.04	7.38E-04
SC- 46	0.03	42.04	0.60	57.07	0.26	3.32E-03
SC- 47	0.20	12.82	5.13	81.62	0.23	3.27E-05
SC- 48	1.80	47.90	3.51	46.71	0.09	9.83E-05
TI- 51	79.94	7.44	12.45	0.17	0.00	3.50E-10
CR- 51	0.04	34.26	0.61	64.94	0.15	3.68E-05
MN- 54	0.01	82.63	0.17	17.10	0.10	3.49E-03
MN- 56	22.41	57.81	7.39	12.39	0.01	1.95E-06
FE- 55	0.00	0.00	0.42	99.32	0.27	2.88E-04
FE- 59	0.03	26.43	0.46	72.93	0.15	2.34E-03
CO- 60	0.00	77.55	0.47	21.68	0.30	4.39E-02
NI- 59	0.00	0.01	0.79	98.67	0.53	1.10E-04
NI- 63	0.00	0.00	0.74	98.76	0.50	2.88E-04
CU- 64	3.47	33.90	7.11	55.46	0.05	2.78E-06
TA-182	0.00	3.76	0.11	96.07	0.05	3.31E-02
W -187	1.60	29.03	3.91	65.40	0.05	1.46E-05
RE-186	0.02	1.57	4.61	93.58	0.23	6.53E-05
RE-188	0.18	2.45	10.33	86.93	0.10	1.58E-05
HG-203	0.00	0.48	0.02	99.48	0.01	2.43E-02
PB-203	0.93	38.29	2.29	58.43	0.07	1.56E-05
PO-210	0.00	0.00	2.09	96.86	1.04	3.83E-01

Table A6: Collective CEDE (manSv) between 1 km to 100 km distance from accidental released activation products (weather sequence W4826B, 10 m release height), unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 hour, population density of 250 people per square kilometer

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	EDE (SV)
HT	0.00	0.00	0.01	99.25	0.73	2.19E-12
HTO	0.00	0.00	0.70	97.92	1.38	9.61E-10
BE- 10	0.00	1.20	0.77	79.96	18.07	2.33E-06
C - 14	0.00	0.00	0.00	99.91	0.09	2.88E-06
N - 13	55.24	43.90	0.38	0.48	0.00	1.47E-10
N - 16	99.47	0.52	0.01	0.00	0.00	2.49E-35
AR- 39	100.00	0.00	0.00	0.00	0.00	1.91E-14
AR- 41	100.00	0.00	0.00	0.00	0.00	2.10E-10
AR- 42	0.30	14.32	0.35	84.94	0.09	1.57E-10
CA- 45	0.00	0.00	0.01	99.81	0.18	3.13E-06
CA- 47	0.01	5.40	0.02	94.52	0.04	1.37E-06
SC- 46	0.00	42.30	0.02	57.42	0.26	6.09E-06
SC- 47	0.03	13.52	0.16	86.05	0.24	5.71E-08
SC- 48	0.30	50.38	0.11	49.12	0.09	1.79E-07
TI- 51	66.73	31.40	1.15	0.72	0.00	2.66E-11
CR- 51	0.01	34.47	0.02	65.35	0.15	6.76E-08
MN- 54	0.00	82.77	0.00	17.12	0.10	6.42E-06
MN- 56	5.58	77.50	0.30	16.61	0.01	4.77E-09
FE- 55	0.00	0.00	0.01	99.72	0.27	5.28E-07
FE- 59	0.00	26.56	0.01	73.27	0.15	4.31E-06
CO- 60	0.00	77.91	0.01	21.77	0.31	8.06E-05
NI- 59	0.00	0.01	0.02	99.43	0.54	2.01E-07
NI- 63	0.00	0.00	0.02	99.47	0.50	5.26E-07
CU- 64	0.62	37.59	0.23	61.49	0.06	5.23E-09
TA-182	0.00	3.77	0.00	96.18	0.05	6.10E-05
W -187	0.27	30.61	0.12	68.95	0.06	2.73E-08
RE-186	0.00	1.64	0.14	97.97	0.24	1.17E-07
RE-188	0.03	2.73	0.34	96.79	0.12	2.86E-08
HG-203	0.00	0.48	0.00	99.51	0.01	4.49E-05
PB-203	0.15	39.47	0.07	60.24	0.07	2.88E-08
PO-210	0.00	0.00	0.06	98.87	1.07	6.93E-04

Table A7: EDE (Sv) of the MEI at 1 km distance from accidentally released activation products (weather sequence W4826S, 150 m release height), unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 hour

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	CEDE (MANSV)
HT	0.00	0.00	0.01	94.81	5.18	5.47E-08
HTO	0.00	0.00	1.44	92.53	6.03	2.67E-06
BE- 10	0.00	1.10	9.19	73.17	16.54	1.64E-03
C - 14	0.00	0.00	0.05	99.86	0.09	1.85E-03
N - 13	73.41	24.77	1.55	0.27	0.00	1.67E-08
N - 16	99.92	0.08	0.00	0.00	0.00	2.44E-33
AR- 39	100.00	0.00	0.00	0.00	0.00	9.18E-11
AR- 41	100.00	0.00	0.00	0.00	0.00	4.46E-07
AR- 42	1.15	13.50	5.19	80.08	0.08	1.89E-06
CA- 45	0.00	0.00	0.13	99.69	0.18	2.02E-03
CA- 47	0.05	5.38	0.27	94.25	0.04	8.75E-04
SC- 46	0.02	42.21	0.23	57.29	0.26	3.93E-03
SC- 47	0.12	13.26	1.99	84.40	0.24	3.75E-05
SC- 48	1.05	49.37	1.36	48.14	0.09	1.14E-04
TI- 51	79.43	16.83	3.36	0.38	0.00	1.97E-09
CR- 51	0.03	34.40	0.23	65.20	0.15	4.36E-05
MN- 54	0.01	82.72	0.06	17.11	0.10	4.14E-03
MN- 56	16.27	66.45	3.03	14.24	0.01	2.26E-06
FE- 55	0.00	0.00	0.16	99.58	0.27	3.41E-04
FE- 59	0.02	26.51	0.17	73.15	0.15	2.77E-03
CO- 60	0.00	77.78	0.18	21.74	0.31	5.20E-02
NI- 59	0.00	0.01	0.30	99.16	0.53	1.30E-04
NI- 63	0.00	0.00	0.28	99.22	0.50	3.40E-04
CU- 64	2.15	36.03	2.83	58.94	0.06	3.20E-06
TA-182	0.00	3.77	0.04	96.14	0.05	3.93E-02
W -187	0.95	29.97	1.51	67.51	0.06	1.71E-05
RE-186	0.01	1.62	1.78	96.36	0.24	7.56E-05
RE-188	0.11	2.62	4.15	93.01	0.11	1.79E-05
HG-203	0.00	0.48	0.01	99.50	0.01	2.89E-02
PB-203	0.54	39.00	0.87	59.52	0.07	1.84E-05
PO-210	0.00	0.00	0.79	98.15	1.06	4.49E-01

Table A8: **Collective CEDE (manSv) between 1 km to 100 km distance from accidentally released activation products (weather sequence W4826S, 150 m release height),** unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 hour, population density of 250 people per square kilometer

Dose results from routine releases

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	EDE (SV)
HT	0.00	0.00	0.03	89.85	10.12	8.53E-14
HTO	0.00	0.00	17.75	79.69	2.56	5.50E-12
BE- 10	0.00	0.87	43.25	42.82	13.07	8.19E-09
C - 14	0.00	0.00	68.99	10.16	20.84	3.09E-11
N - 13	92.91	4.24	2.81	0.03	0.00	4.90E-12
N - 16	99.92	0.03	0.05	0.00	0.00	2.20E-25
AR- 39	100.00	0.00	0.00	0.00	0.00	7.84E-16
AR- 41	100.00	0.00	0.00	0.00	0.00	8.79E-12
AR- 42	4.61	12.61	24.10	58.60	0.08	2.85E-13
CA- 45	0.00	0.00	1.02	98.74	0.24	5.95E-09
CA- 47	0.33	6.97	2.12	90.52	0.06	2.69E-09
SC- 46	0.10	48.77	1.57	49.26	0.30	1.34E-08
SC- 47	0.64	14.97	13.42	70.71	0.27	1.31E-10
SC- 48	5.17	50.18	8.27	36.29	0.09	4.55E-10
TI- 51	90.59	2.45	6.92	0.04	0.00	1.31E-12
CR- 51	0.14	40.76	1.61	57.30	0.18	1.45E-10
MN- 54	0.04	86.10	0.39	13.37	0.10	1.56E-08
MN- 56	46.35	36.90	10.89	5.85	0.01	2.58E-11
FE- 55	0.00	0.00	1.24	98.40	0.36	1.01E-09
FE- 59	0.10	32.33	1.26	66.14	0.18	8.95E-09
CO- 60	0.01	81.55	1.10	17.03	0.32	1.95E-07
NI- 59	0.00	0.01	2.24	97.07	0.68	4.02E-10
NI- 63	0.00	0.00	2.13	97.23	0.64	1.05E-09
CU- 64	9.72	33.53	16.01	40.68	0.05	1.49E-11
TA-182	0.01	5.00	0.32	94.60	0.07	1.16E-07
W -187	4.89	31.96	9.72	53.37	0.06	6.64E-11
RE-186	0.06	1.92	12.67	85.07	0.28	2.53E-10
RE-188	0.56	2.69	25.75	70.88	0.11	7.36E-11
HG-203	0.00	0.65	0.07	99.27	0.01	8.47E-08
PB-203	2.84	42.84	5.76	48.48	0.08	6.73E-11
PO-210	0.00	0.00	6.03	92.62	1.35	1.39E-06

Table A9: EDE (Sv) of the MEI at 1 km distance from routine releases of activation products (meteorological station Karlsruhe, 150 m release height), unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 year

NUCLIDE	CL %	GR %	IH %	IG %	IHR %	CEDE (MANSV)
HT	0.00	0.00	0.03	78.29	21.68	1.70E-08
HTO	0.00	0.00	21.93	67.37	10.70	4.26E-07
BE- 10	0.00	0.53	70.99	20.51	7.97	5.95E-04
C - 14	0.00	0.00	86.57	3.72	9.72	2.94E-06
N - 13	94.96	2.16	2.87	0.01	0.00	1.55E-08
N - 16	99.91	0.04	0.05	0.00	0.00	3.72E-23
AR- 39	100.00	0.00	0.00	0.00	0.00	9.94E-11
AR- 41	100.00	0.00	0.00	0.00	0.00	2.98E-07
AR- 42	9.46	8.78	49.44	32.27	0.05	6.59E-07
CA- 45	0.00	0.00	3.42	96.29	0.30	2.13E-04
CA- 47	1.04	8.26	6.75	83.89	0.07	9.78E-05
SC- 46	0.29	52.82	4.56	42.00	0.33	5.46E-04
SC- 47	1.58	13.79	33.26	51.12	0.25	6.28E-06
SC- 48	12.05	43.84	19.29	24.75	0.08	2.15E-05
TI- 51	91.64	1.34	7.00	0.02	0.00	2.28E-09
CR- 51	0.42	44.99	4.79	49.59	0.20	5.78E-06
MN- 54	0.10	87.88	1.06	10.85	0.10	6.78E-04
MN- 56	62.29	20.63	14.64	2.44	0.00	7.54E-07
FE- 55	0.00	0.00	4.12	95.44	0.44	3.61E-05
FE- 59	0.29	36.73	3.84	58.93	0.21	3.48E-04
CO- 60	0.03	82.95	3.00	13.69	0.33	8.49E-03
NI- 59	0.00	0.01	7.00	92.20	0.79	1.54E-05
NI- 63	0.00	0.00	6.70	92.55	0.75	3.98E-05
CU- 64	19.25	25.30	31.71	23.70	0.04	6.94E-07
TA-182	0.03	6.24	1.09	92.57	0.09	4.13E-03
W -187	11.56	28.46	22.99	36.94	0.05	2.91E-06
RE-186	0.17	1.87	32.99	64.70	0.27	1.12E-05
RE-188	1.16	2.12	53.45	43.18	0.09	3.48E-06
HG-203	0.01	0.82	0.25	98.91	0.01	2.95E-03
PB-203	7.31	41.28	14.84	36.49	0.07	2.92E-06
PO-210	0.00	0.00	17.99	80.51	1.49	5.55E-02

Table A10: **Collective CEDE (manSv) between 1 km to 100 km distance from routine release of activation products (meteorological station Karlsruhe, 150 m release height),** unit release rate of 1.0 E+09 Bq / nuclide, release duration of 1 year, population density of 250 people per square kilometer

Appendix B

Meteorological data

Release in the night (24 hours)

THE FIRST HOUR OF THIS DATASET IS THE HOUR OF THE RELEASE

ORDER OF PARAMETERS:

CODE NUMBER
TIME OF DAY (NUMBER OF HOUR)
STABILITY CLASS ACCORDING TO THE PASQUILL-GIFFORD NOTATION
(1 = VERY UNSTABLE, ..., 6 = VERY STABLE)
WIND DIRECTION (WIND COMES FROM...; N OVER O POSITIVE) <DEGREE>
WIND SPEED IN A HEIGTH OF 10 M ABOVE GROUND SURFACE <M/S>
RAIN INTENSITY <MM/H>
AIR TEMPERATURE IN A HEIGTH OF 2 M ABOVE GROUND SURFACE <DEGREE C>
NET RADIATION BALANCE TO A HORIZONTAL PLAIN SURFACE <WATT/M**2>
PRESSURE <HPA>
RELATIVE HUMIDITY (0.0 .... 1.0)

NR.	TIME	STAB.	DIR.	SPEED	RAIN	TEMP.	RAD.	PRESS.	REL.H.
1	2	6	60	0.50	0.00	3.19	-90	999.1	0.92
2	3	6	60	0.50	0.00	2.50	-95	998.9	0.92
3	4	6	60	0.50	0.00	2.10	-82	999.0	0.93
4	5	6	60	0.50	0.00	2.00	-59	999.1	0.97
5	6	6	60	0.50	0.00	2.39	45	999.3	1.00
6	7	6	60	1.00	0.00	3.50	103	999.5	0.99
7	8	5	60	0.50	0.00	5.39	227	999.7	0.91
8	9	3	60	1.00	0.00	7.60	207	999.6	0.80
9	10	3	60	2.60	0.00	9.60	129	999.4	0.71
10	11	3	30	3.60	0.00	10.80	141	999.0	0.66
11	12	3	165	3.10	0.00	11.39	148	998.8	0.63
12	13	2	300	1.00	0.00	11.60	150	998.7	0.62
13	14	2	270	0.50	0.00	11.60	144	998.8	0.63
14	15	3	320	2.00	0.00	11.39	133	999.0	0.65
15	16	3	250	3.10	0.00	11.30	116	999.1	0.67
16	17	3	290	1.50	0.00	11.30	91	999.1	0.67
17	18	3	330	3.10	0.00	11.30	61	999.0	0.67
18	19	4	330	2.60	0.00	11.19	30	998.8	0.67
19	20	4	340	2.00	0.00	10.89	0	998.6	0.68
20	21	5	10	1.00	0.00	10.30	-26	998.4	0.71
21	22	6	115	0.50	0.00	9.30	-37	998.2	0.76
22	23	6	220	1.00	0.00	7.89	-40	998.0	0.82
23	24	6	215	0.50	0.00	6.50	-35	997.7	0.88
24	1	6	210	2.00	0.00	5.39	-38	997.4	0.93

Release during very unstable conditions (24 hours)

THE FIRST HOUR OF THIS DATASET IS THE HOUR OF THE RELEASE

ORDER OF PARAMETERS:

CODE NUMBER
TIME OF DAY (NUMBER OF HOUR)
STABILITY CLASS ACCORDING TO THE PASQUILL-GIFFORD NOTATION
(1 = VERY UNSTABLE, ..., 6 = VERY STABLE)
WIND DIRECTION (WIND COMES FROM...; N OVER O POSITIVE) <DEGREE>
WIND SPEED IN A HEIGTH OF 10 M ABOVE GROUND SURFACE <M/S>
RAIN INTENSITY <MM/H>
AIR TEMPERATURE IN A HEIGTH OF 2 M ABOVE GROUND SURFACE <DEGREE C>
NET RADIATION BALANCE TO A HORIZONTAL PLAIN SURFACE <WATT/M**2>
PRESSURE <HPA>
RELATIVE HUMIDITY (0.0 .... 1.0)

NR.	TIME	STAB.	DIR.	SPEED	RAIN	TEMP.	RAD.	PRESS.	REL.H.
1	12	1	110	1.50	0.00	19.30	469	1006.9	0.47
2	13	1	270	0.50	0.00	20.19	722	1006.5	0.45
3	14	1	80	0.50	0.00	20.69	475	1006.0	0.45
4	15	1	30	1.50	0.00	21.00	609	1005.5	0.45
5	16	1	270	1.50	0.00	21.19	586	1005.1	0.45
6	17	2	330	0.50	0.00	21.39	277	1004.6	0.44
7	18	2	300	0.50	0.00	21.39	302	1004.3	0.44
8	19	4	60	0.50	0.00	21.00	63	1004.3	0.45
9	20	4	100	0.50	0.00	19.69	-9	1004.4	0.50
10	21	5	70	3.10	0.00	17.89	-54	1004.7	0.58
11	22	5	90	2.00	0.00	16.10	-56	1004.9	0.67
12	23	4	80	4.10	0.00	14.50	-59	1004.9	0.75
13	24	6	70	0.50	0.00	13.19	-78	1004.7	0.81
14	1	6	40	1.00	0.00	12.10	-102	1004.5	0.86
15	2	6	30	0.50	0.00	11.10	-113	1004.4	0.90
16	3	6	20	2.00	0.00	10.50	-112	1004.4	0.91
17	4	6	60	1.50	0.00	10.30	-105	1004.4	0.92
18	5	6	60	1.50	0.00	10.80	-86	1004.4	0.92
19	6	6	40	1.00	0.00	11.89	1	1004.4	0.89
20	7	5	50	2.00	0.00	13.60	184	1004.4	0.81
21	8	5	60	0.50	0.00	11.19	307	1007.5	0.82
22	9	2	20	0.50	0.00	13.69	371	1007.5	0.68
23	10	2	30	1.00	0.00	16.00	633	1007.4	0.58
24	11	1	190	1.00	0.00	17.89	684	1007.2	0.51

Weather sequence W2791 (24 hours)

THE FIRST HOUR OF THIS DATASET IS THE HOUR OF THE RELEASE

ORDER OF PARAMETERS:

CODE NUMBER
TIME OF DAY (NUMBER OF HOUR)
STABILITY CLASS ACCORDING TO THE PASQUILL-GIFFORD NOTATION
(1 = VERY UNSTABLE, ..., 6 = VERY STABLE)
WIND DIRECTION (WIND COMES FROM...; N OVER O POSITIVE) <DEGREE>
WIND SPEED IN A HEIGTH OF 10 M ABOVE GROUND SURFACE <M/S>
RAIN INTENSITY <MM/H>
AIR TEMPERATURE IN A HEIGTH OF 2 M ABOVE GROUND SURFACE <DEGREE C>
NET RADIATION BALANCE TO A HORIZONTAL PLAIN SURFACE <WATT/M**2>
PRESSURE <HPA>
RELATIVE HUMIDITY (0.0 .... 1.0)

NR.	TIME	STAB.	DIR.	SPEED	RAIN	TEMP.	RAD.	PRESS.	REL.H.
1	7	6	305	0.50	0.00	3.19	56	994.1	0.93
2	8	5	101	0.50	0.00	5.10	120	994.3	0.88
3	9	5	328	0.50	0.00	7.60	399	994.6	0.79
4	10	2	166	0.50	0.00	10.10	558	994.8	0.68
5	11	2	240	1.50	0.00	12.30	634	994.8	0.56
6	12	2	320	1.50	0.00	14.10	564	994.3	0.46
7	13	2	270	2.00	0.00	15.39	715	993.6	0.40
8	14	2	310	3.10	0.00	16.10	699	992.9	0.37
9	15	2	180	0.50	0.00	16.39	637	992.3	0.37
10	16	2	50	3.10	0.00	16.39	428	991.9	0.38
11	17	2	40	0.50	0.00	16.30	329	991.6	0.39
12	18	4	46	0.50	0.00	15.69	111	991.3	0.42
13	19	4	48	0.50	0.00	14.50	20	991.2	0.46
14	20	6	40	1.50	0.00	12.39	-73	991.2	0.52
15	21	6	40	2.00	0.00	10.00	-85	991.4	0.60
16	22	6	60	1.50	0.00	8.19	-67	991.7	0.67
17	23	6	70	1.50	0.00	7.39	-45	991.9	0.72
18	24	5	60	2.60	0.00	7.19	-61	992.0	0.75
19	1	5	60	2.60	0.00	7.00	-90	991.9	0.77
20	2	5	50	2.60	0.00	6.19	-101	991.8	0.79
21	3	6	60	1.50	0.00	5.00	-99	991.8	0.84
22	4	6	60	2.00	0.00	4.00	-97	991.9	0.88
23	5	6	60	2.00	0.00	3.50	-96	991.9	0.92
24	6	6	50	2.00	0.00	3.80	-59	991.9	0.92

Weather sequence W4826 (24 hours)

THE FIRST HOUR OF THIS DATASET IS THE HOUR OF THE RELEASE

ORDER OF PARAMETERS:

CODE NUMBER	
TIME OF DAY (NUMBER OF HOUR)	
STABILITY CLASS ACCORDING TO THE PASQUILL-GIFFORD NOTATION (1 = VERY UNSTABLE, ..., 6 = VERY STABLE)	
WIND DIRECTION (WIND COMES FROM...; N OVER O POSITIVE)	<DEGREE>
WIND SPEED IN A HEIGTH OF 10 M ABOVE GROUND SURFACE	<M/S>
RAIN INTENSITY	<MM/H>
AIR TEMPERATURE IN A HEIGTH OF 2 M ABOVE GROUND SURFACE	<DEGREE C>
NET RADIATION BALANCE TO A HORIZONTAL PLAIN SURFACE	<WATT/M**2>
PRESSURE	<HPA>
RELATIVE HUMIDITY (0.0 .... 1.0)	

NR.	TIME	STAB.	DIR.	SPEED	RAIN	TEMP.	RAD.	PRESS.	REL.H.
1	2	5	170	0.50	1.30	15.19	-8	1001.7	0.97
2	3	5	200	0.50	1.19	15.30	-15	1001.4	0.97
3	4	5	230	1.00	1.10	15.30	-15	1001.2	0.97
4	5	6	210	1.50	0.69	15.19	-20	1001.0	0.98
5	6	5	250	3.10	0.69	15.10	14	1000.8	1.00
6	7	5	220	2.60	0.60	15.30	81	1000.8	0.99
7	8	5	210	1.50	0.00	16.00	258	1000.8	0.95
8	9	3	190	1.50	0.00	17.00	420	1000.8	0.88
9	10	3	240	1.50	0.00	18.10	242	1000.8	0.81
10	11	2	240	1.50	0.00	18.89	381	1000.8	0.77
11	12	2	300	2.60	0.00	19.60	771	1000.8	0.73
12	13	2	290	3.10	0.00	20.10	655	1000.9	0.72
13	14	2	290	3.60	0.19	20.50	567	1000.8	0.70
14	15	2	260	4.60	0.00	20.89	540	1000.6	0.69
15	16	3	250	4.60	0.00	21.19	236	1000.4	0.67
16	17	4	230	5.60	0.00	21.50	174	1000.2	0.64
17	18	3	240	2.00	0.00	21.60	186	1000.2	0.62
18	19	3	240	2.60	0.00	21.10	62	1000.3	0.63
19	20	3	190	2.60	0.00	20.00	-25	1000.5	0.68
20	21	4	210	5.10	0.00	18.39	-75	1000.7	0.78
21	22	4	190	4.60	0.00	17.00	-59	1001.0	0.87
22	23	5	210	2.60	0.00	16.00	-47	1001.1	0.92
23	24	6	140	2.00	0.00	15.39	-38	1001.3	0.93
24	1	5	200	2.00	0.00	15.10	-25	1001.3	0.92

Appendix C

Dose results from mobilisation source terms

RPM-scenario 1

NO.	NUCLIDE	BQ
1	HT	0.13702E+12
6	NA- 24	0.47011E+08
31	SC- 46	0.46368E+07
32	SC- 47	0.33715E+07
33	SC- 48	0.56841E+07
36	V - 49	0.15895E+07
37	CR- 51	0.34467E+08
39	MN- 54	0.38329E+08
40	MN- 56	0.12198E+07
41	FE- 55	0.35596E+09
45	CO- 57	0.73821E+08
46	CO- 58M	0.49060E+07
47	CO- 58	0.68644E+08
48	CO- 60M	0.93223E-02
49	CO- 60	0.44985E+07
99	MO- 99	0.25764E+06
101	TC- 99M	0.22152E+06
102	TC- 99	0.46040E-03
273	PU-238	0.16877E+04
274	PU-239	0.72197E+02
276	PU-241	0.93746E+02
282	CM-242	0.15850E+01

Table C1: Nuclide list and total release rate for source term RPM 1-Be (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.12	55.15	4.98	39.44	0.30	3.95E-08
CEDE (manSv)	0.30	55.25	4.69	39.48	0.30	7.83E-05
Early dose (Sv)	1.89	22.05	75.55	0.00	0.51	2.60E-09

Table C2: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from RPM 1-Be scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
1	HT	0.68000E+07
230	HF-181	0.22833E+10
232	TA-179	0.13518E+11
233	TA-182	0.31343E+12
234	TA-183	0.76160E+10
235	W -181	0.31355E+13
236	W -185	0.46825E+13
237	W -187	0.53455E+12
238	W -188	0.17078E+08
239	RE-184	0.24308E+12
240	RE-184M	0.35156E+11
241	RE-186	0.55014E+12
243	RE-188	0.59926E+11
244	RE-188M	0.53432E+05
245	OS-185	0.20120E+11

Table C3: Nuclide list and total release rate for source term RPM 1-Tu (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.01	4.22	1.19	94.52	0.05	9.18E-04
CEDE (manSv)	0.04	4.22	1.11	94.58	0.05	1.82E+00
Early dose (Sv)	1.03	16.20	82.10	0.14	0.54	1.33E-05

Table C4: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from RPM 1-Tu scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
1	HT	6.1E+14

Table C5: Nuclide list and total release rate for source term RPM 1-HT (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	0.00	0.01	98.61	1.37	1.07E-05
CEDE (manSV)	0.00	0.00	0.01	94.97	5.03	3.76E-02
Early dose (Sv)	0.00	0.00	0.07	00.00	99.93	1.48E-07

Table C6: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from RPM 1-HT scenario (W4826, 10 m release height, 60 release phases)

RPM-scenario 2

NO.	NUCLIDE	BQ
1	HT	0.63271E+13
6	NA- 24	0.38861E+08
31	SC- 46	0.20979E+07
32	SC- 47	0.17056E+07
33	SC- 48	0.31823E+07
36	V - 49	0.71667E+06
37	CR- 51	0.15742E+08
39	MN- 54	0.17283E+08
40	MN- 56	0.87842E+07
41	FE- 55	0.16037E+09
45	CO- 57	0.33292E+08
46	CO- 58M	0.58626E+07
47	CO- 58	0.31064E+08
48	CO- 60M	0.26562E+04
49	CO- 60	0.20262E+07
99	MO- 99	0.13368E+06
101	TC- 99M	0.84378E+05
102	TC- 99	0.12496E-03
273	PU-238	0.76003E+03
274	PU-239	0.32513E+02
276	PU-241	0.42220E+02
282	CM-242	0.71549E+00

Table C6: **Nuclide list and total release rate for source term RPM 2-Be (W4826, 10 m release height, 60 release pahases)**

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.02	55.50	0.05	44.10	0.34	3.72E-08
CEDE (manSv)	0.05	23.55	0.42	73.12	2.87	1.82E-04
Early dose (Sv)	0.85	95.13	2.34	0.00	1.68	7.47E-10

Table C9: **EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from RPM 2-Be scenario (W4826, 10 m release height, 60 release phases)**

NO.	NUCLIDE	BQ
1	HT	0.31400E+09
230	HF-181	0.10740E+10
232	TA-179	0.63041E+10
233	TA-182	0.14658E+12
234	TA-183	0.38302E+10
235	W -181	0.14661E+13
236	W -185	0.21937E+13
237	W -187	0.36628E+12
238	W -188	0.80043E+07
239	RE-184	0.11433E+12
240	RE-184M	0.16424E+11
241	RE-186	0.28433E+12
243	RE-188	0.47731E+11
244	RE-188M	0.26391E+09
245	OS-185	0.94151E+10

Table C9: **Nuclide list and total release rate for source term RPM 2-Tu (W4826, 10 m release height, 60 release pahases)**

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	4.29	0.01	95.65	0.05	9.18E-04
CEDE (manSv)	0.01	4.28	0.22	95.45	0.05	1.90E+00
Early dose (Sv)	1.03	16.20	82.10	0.14	0.54	1.33E-05

Table C10: **EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from RPM 2-Tu scenario (W4826, 10 m release height, 60 release phases)**

NO.	NUCLIDE	BQ
1	HT	2.8E+16

Table C11: **Nuclide list and total release rate for source term RPM 2-HT (W4826, 10 m release height, 60 release pahases)**

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	0.00	0.01	99.34	0.64	2.73E-05
CEDE (Sv)	0.00	0.00	0.01	95.34	4.66	6.80E-01
Early dose (Sv)	0.00	0.00	1.56	00.00	98.44	1.78E-07

Table C12: **EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from RPM 2-HT scenario (W4826, 10 m release height, 60 release phases)**

RPM-scenario 3

NO.	NUCLIDE	BQ
1	HT	0.31625E+09
1	HTO	0.31625E+09
6	NA- 24	0.18144E+07
31	SC- 46	0.46258E+06
32	SC- 47	0.18083E+06
33	SC- 48	0.24781E+06
36	V - 49	0.16408E+06
37	CR- 51	0.31554E+07
39	MN- 54	0.39541E+07
40	MN- 56	0.35996E+06
41	FE- 55	0.37037E+08
45	CO- 57	0.76010E+07
46	CO- 58M	0.22296E+06
47	CO- 58	0.67945E+07
48	CO- 60M	0.93100E+04
49	CO- 60	0.46897E+06
99	MO- 99	0.12900E+05
101	TC- 99M	0.10838E+05
102	TC- 99	0.11349E-03
273	PU-238	0.17628E+03
274	PU-239	0.75421E+01
276	PU-241	0.97859E+01
282	CM-242	0.16165E+00

Table C13: **Nuclide list and total release rate for source term RPM 3-Be (W4826, 10 m release height, 60 release pahases)**

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.02	57.82	0.08	41.78	0.31	2.44E-09
CEDE (manSv)	0.13	56.34	3.19	40.06	0.30	6.11E-06
Early dose (Sv)	0.65	80.76	3.62	13.44	1.54	1.76E-10

Table C14: **EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from RPM 3-Be scenario (W4826, 10 m release height, 60 release phases)**

NO.	NUCLIDE	BQ
1	HT	0.15700E+05
1	HTO	0.15700E+05
230	HF-181	0.15700E+09
232	TA-179	0.96069E+09
233	TA-182	0.21852E+11
234	TA-183	0.37928E+09
235	W -181	0.21886E+12
236	W -185	0.32259E+12
237	W -187	0.18967E+11
238	W -188	0.11732E+07
239	RE-184	0.16331E+11
240	RE-184M	0.24681E+10
241	RE-186	0.25410E+11
243	RE-188	0.21365E+10
244	RE-188M	0.14560E+09
245	OS-185	0.13968E+10

Table C15: Nuclide list and total release rate for source term RPM-3-Tu (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	4.29	0.01	95.65	0.05	5.88E-05
CEDE (manSv)	0.02	4.25	0.62	95.08	0.05	9.87E-02
Early dose (Sv)	0.37	93.04	3.67	0.01	2.90	1.62E-07

Table C16: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from RPM 3-Tu scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
1	HT	1.4E+13
2	HTO	1.4E+13

Table C17: Nuclide list and total release rate for source term RPM 3-HT (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	0.00	3.83	94.70	1.47	3.10E-07
CEDE (manSv)	0.00	0.00	5.31	89.18	5.51	1.40E-02
Early dose (Sv)	0.00	0.00	70.92	0.00	29.08	1.67E-08

Table C18: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from RPM 3-HT scenario (W4826, 10 m release height, 60 release phases)

APM-scenario 1

NO.	NUCLIDE	BQ
48	CO- 60M	0.65867E+11
49	CO- 60	0.47320E+12
53	NI- 63	0.74465E+11
54	NI- 65	0.24923E+11
55	CU- 64	0.44322E+13
57	ZN- 65	0.32997E+11
113	AG-110M	0.47871E+11
114	AG-111	0.20560E+10
115	CD-109	0.64605E+10

Table C19: Nuclide list and total release rate for source term APM-11 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.02	71.20	3.03	25.47	0.28	1.77E-03
CEDE (manSc)	0.04	71.23	2.94	25.51	0.29	3.56E+00
Early dose (Sv)	0.51	10.32	88.31	0.03	0.84	6.06E-05

Table C20: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 1.1 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
36	V - 49	0.36474E+11
37	CR- 51	0.28756E+12
39	MN- 54	0.11959E+13
40	MN- 56	0.39923E+12
41	FE- 55	0.10724E+14
42	FE- 59	0.13802E+11
49	CO- 60	0.15938E+10
233	TA-182	0.29563E+12
234	TA-183	0.20704E+10
235	W -181	0.26536E+11
236	W -185	0.10300E+12
237	W -187	0.77410E+11
241	RE-186	0.49887E+10
243	RE-188	0.13475E+11

Table C21: Nuclide list and total release rate for source term APM-12 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.01	22.47	0.50	76.92	0.10	3.91E-03
CEDE (manSv)	0.03	22.41	0.68	76.79	0.10	4.46E+00
Early dose (Sv)	0.89	46.74	51.13	0.05	1.20	3.81E-05

Table C22: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 12 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
48	CO- 60M	0.64519E+11
49	CO- 60	0.46343E+12
53	NI- 63	0.72936E+11
54	NI- 65	0.24423E+11
55	CU- 64	0.43413E+13
57	ZN- 65	0.32320E+11
113	AG-110M	0.46913E+11
230	HF-181	0.65396E+10
232	TA-179	0.35601E+10
233	TA-182	0.38599E+12
234	TA-183	0.91444E+12
235	W -181	0.97111E+12
236	W -185	0.74140E+13
237	W -187	0.14974E+14
239	RE-184	0.68463E+11
240	RE-184M	0.52844E+10
241	RE-186	0.73723E+13
243	RE-188	0.21606E+14
244	RE-188M	0.38927E+13

Table C23: Nuclide list and total release rate for source term APM-21 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.05	38.89	3.10	57.78	0.17	3.37E-03
CEDE (manSv)	0.11	39.03	2.91	57.78	0.18	6.65E+00
Early dose (Sv)	1.30	12.52	85.57	0.02	0.60	1.22E-04

Table C24: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 21 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
36	V - 49	0.36420E+11
37	CR- 51	0.28805E+12
39	MN- 54	0.11950E+13
40	MN- 56	0.39864E+12
41	FE- 55	0.10711E+14
42	FE- 59	0.13776E+11
49	CO- 60	0.15903E+10
233	TA-182	0.31980E+12
234	TA-183	0.60447E+11
235	W -181	0.88359E+11
236	W -185	0.57505E+12
237	W -187	0.10309E+13
239	RE-184	0.43617E+10
240	RE-184M	0.33658E+09
241	RE-186	0.47464E+12
243	RE-188	0.13894E+13
244	RE-188M	0.24797E+12
246	OS-191	0.12091E+12
248	IR-192	0.54940E+10

Table C25: Nuclide list and total release rate for source term APM-22 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.01	20.82	0.55	78.52	0.10	4.27E-03
CEDE (manSv)	0.03	20.77	0.75	78.37	0.10	4.87E+00
Early dose (Sv)	0.99	44.30	53.53	0.04	1.14	4.43E-05

Table C26: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 22 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
1	HTO	7.87E+14

Table C27: Nuclide list and total release rate for source term APM 1-HTO (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	0.00	12.05	86.65	1.30	3.14E-04
CEDE (manSv)	0.00	0.00	4.62	90.47	4.92	1.27E+00
Early dose (Sv)	0.00	0.00	90.25	0.00	9.75	4.20E-05

Table C28: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 1-HTO scenario (W4826, 10 m release height, 60 release phases)

APM-scenario 2

NO.	NUCLIDE	BQ
48	CO- 60M	0.43594E+11
49	CO- 60	0.31312E+12
53	NI- 63	0.49262E+11
54	NI- 65	0.16488E+11
55	CU- 64	0.29345E+13
57	ZN- 65	0.21834E+11
113	AG-110M	0.31660E+11
114	AG-111	0.13599E+10
115	CD-109	0.42764E+10

Table C29: Nuclide list and total release rate for source term APM-11-2 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	73.43	0.01	26.26	0.29	1.09E-02
CEDE (manSv)	0.00	73.22	0.29	26.20	0.29	1.06E+01
Early dose (Sv)	0.22	89.12	3.39	0.04	7.23	4.45E-05

Table C30: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 11-2 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
36	V - 49	0.50280E+11
37	CR- 51	0.30860E+12
39	MN- 54	0.16526E+13
40	MN- 56	0.55325E+12
41	FE- 55	0.14816E+14
42	FE- 59	0.19074E+11
49	CO- 60	0.21992E+10
233	TA-182	0.40836E+12
234	TA-183	0.28582E+10
235	W -181	0.36665E+11
236	W -185	0.14227E+12
237	W -187	0.10690E+12
241	RE-186	0.68285E+10
243	RE-188	0.18438E+11

Table C31: Nuclide list and total release rate for source term APM-21-2 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	22.56	0.01	77.33	0.10	3.57E-02
CEDE (manSv)	0.00	22.55	0.07	77.28	0.10	2.60E+01
Early dose (Sv)	0.22	96.19	1.11	0.01	2.47	1.70E-04

Table C32: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 12-2 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
48	CO- 60M	0.43152E+11
49	CO- 60	0.30992E+12
53	NI- 63	0.48767E+11
54	NI- 65	0.16315E+11
55	CU- 64	0.29050E+13
57	ZN- 65	0.21608E+11
113	AG-110M	0.31349E+11
230	HF-181	0.43707E+10
232	TA-179	0.23793E+10
233	TA-182	0.25799E+12
234	TA-183	0.61127E+12
235	W -181	0.64930E+12
236	W -185	0.49565E+13
237	W -187	0.10001E+14
239	RE-184	0.45779E+11
240	RE-184M	0.35325E+10
241	RE-186	0.49278E+13
243	RE-188	0.14432E+14
244	RE-188M	0.26029E+13

Table C33: Nuclide list and total release rate for source term APM-21-2 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	40.20	0.01	59.60	0.18	2.07E-02
CEDE (manSv)	0.01	40.12	0.29	59.41	0.18	2.01E+01
Early dose (Sv)	0.48	92.28	2.83	0.02	4.39	1.05E-04

Table C34: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 21-2 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
36	V - 49	0.50485E+11
37	CR- 51	0.40692E+12
39	MN- 54	0.16523E+13
40	MN- 56	0.55342E+12
41	FE- 55	0.14818E+14
42	FE- 59	0.19081E+11
49	CO- 60	0.22010E+10
233	TA-182	0.44238E+12
234	TA-183	0.83550E+11
235	W -181	0.12191E+12
236	W -185	0.79414E+12
237	W -187	0.14234E+13
239	RE-184	0.60085E+10
240	RE-184M	0.46440E+09
241	RE-186	0.65429E+12
243	RE-188	0.19183E+13
244	RE-188M	0.34207E+12
246	OS-191	0.17781E+12
248	IR-192	0.75759E+10

Table C35: Nuclide list and total release rate for source term APM-22-2 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	20.89	0.01	79.01	0.10	3.91E-02
CEDE (manSv)	0.00	20.88	0.08	78.94	0.10	2.84E+01
Early dose (Sv)	0.26	96.04	1.21	0.01	2.47	1.88E-04

Table C36: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 22-2 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
1	HTO	1.85E+16

Table C37: **Nuclide list and total release rate for source term APM 2-HTO (W4826, 10 m release height, 60 release pahases)**

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	0.00	6.90	92.55	0.55	8.86E-04
CEDE (manSv)	0.00	0.00	4.54	91.01	4.46	1.64E+01
Early dose (Sv)	0.00	0.00	92.62	0.00	7.38	6.60E-05

Table C38: **EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM HTO-2 scenario (W4826, 10 m release height, 60 release phases)**

APM-scenario 3

NO.	NUCLIDE	BQ
48	CO- 60M	0.18270E+00
49	CO- 60	0.25987E+10
53	NI- 63	0.40528E+09
54	NI- 65	0.49218E+07
55	CU- 64	0.70043E+10
57	ZN- 65	0.18015E+09
113	AG-110M	0.28729E+06
114	AG-111	0.96245E+07
115	CD-109	0.43106E+08

Table C39: Nuclide list and total release rate for source term APM-11-3 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	75.00	0.03	24.67	0.30	2.44E-05
CEDE (manSv)	0.01	74.70	0.43	24.57	0.30	5.97E-02
Early dose (Sv)	0.26	85.56	6.56	0.00	7.61	9.56E-08

Table C40: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 11-3 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
36	V - 49	0.17240E+09
37	CR- 51	0.30638E+10
39	MN- 54	0.55033E+10
40	MN- 56	0.16652E+09
41	FE- 55	0.49711E+11
42	FE- 59	0.63005E+08
49	CO- 60	0.75251E+07
233	TA-182	0.13626E+10
234	TA-183	0.84453E+07
235	W -181	0.12226E+11
236	W -185	0.47298E+11
237	W -187	0.21428E+11
241	RE-186	0.20498E+10
243	RE-188	0.34213E+10

Table C41: Nuclide list and total release rate for source term APM-21-3 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	16.10	0.01	83.80	0.08	5.66E-05
CEDE (manSv)	0.01	16.12	0.11	83.68	0.08	8.50E-02
Early dose (Sv)	0.35	96.19	1.21	0.00	2.25	2.70E-07

Table C42: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 12-3 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
48	CO- 60M	0.18165E+00
49	CO- 60	0.25670E+10
53	NI- 63	0.40073E+09
54	NI- 65	0.48880E+07
55	CU- 64	0.69028E+10
57	ZN- 65	0.17800E+09
113	AG-110M	0.28306E+06
230	HF-181	0.18409E+09
232	TA-179	0.10312E+09
233	TA-182	0.11074E+11
234	TA-183	0.21247E+11
235	W -181	0.27877E+11
236	W -185	0.21138E+12
237	W -187	0.19380E+12
239	RE-184	0.19210E+10
240	RE-184M	0.15209E+09
241	RE-186	0.16040E+12
243	RE-188	0.22643E+12
244	RE-188M	0.91145E+08

Table C43: Nuclide list and total release rate for source term APM-21-3 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	16.69	0.02	83.19	0.10	1.29E-04
CEDE (manSv)	0.02	16.35	0.34	83.20	0.10	3.18E-01
Early dose (Sv)	0.73	91.88	4.18	0.00	3.21	6.63E-07

Table C44: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 21-3 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
36	V - 49	0.17023E+09
37	CR- 51	0.30479E+10
39	MN- 54	0.54241E+10
40	MN- 56	0.16619E+09
41	FE- 55	0.49092E+11
42	FE- 59	0.62249E+08
49	CO- 60	0.73961E+07
233	TA-182	0.19998E+10
234	TA-183	0.14028E+10
235	W -181	0.17734E+10
236	W -185	0.13039E+11
237	W -187	0.16586E+11
239	RE-184	0.11507E+09
240	RE-184M	0.90021E+07
241	RE-186	0.10839E+11
243	RE-188	0.20927E+11
244	RE-188M	0.53109E+08
246	OS-191	0.31034E+10
248	IR-192	0.14503E+09

Table C45: Nuclide list and total release rate for source term APM-22-3 (W4826, 10 m release height, 60 release pahases)

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	15.69	0.01	84.22	0.09	5.96E-05
CEDE (manSv)	0.01	15.69	0.15	84.08	0.08	8.93E-02
Early dose (Sv)	0.33	95.54	1.61	0.00	2.52	2.91E-07

Table C46: EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM 22-3 scenario (W4826, 10 m release height, 60 release phases)

NO.	NUCLIDE	BQ
1	HTO	1.85E+13

Table C47: **Nuclide list and total release rate for source term APM 3-HTO (W4826, 10 m release height, 60 release pahases)**

case	CL	GR	IH	IG	IHR	dose
EDE (Sv)	0.00	0.00	2.87	95.70	1.43	3.60E-07
CEDE (manSv)	0.00	0.00	5.34	89.56	5.11	1.93E-02
Early dose (Sv)	0.00	0.00	66.74	0.00	33.26	1.55E-06

Table C48: **EDE (Sv) and early dose (Sv) of the MEI at 1 km distance and collective dose (manSv) between 1 and 100 km (250 persons per km2) from APM HTO-3 scenario (W4826, 10 m release height, 60 release phases)**