Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft
Wissenschaftliche Berichte
FZKA 6946

Parametric Studies on Environmental Doses for Hypothetical Fusion Plant Fire Accidents

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Institut für Kern- und Energietechni

Februar 2004

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TW3-TSS-SEP2 – Final report

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Programm Kernfusion

Forschungszentrum Karlsruhe GmbH, Karlsruhe

2004

Impressum der Print-Ausgabe:

Als Manuskript gedruckt

Forschungszentrum Karlsruhe GmbH
Postfach 3640, 76021 Karlsruhe

Mitglied der Hermann von Helmholtz-Gemeinschaft
Deutscher Forschungszentren (HGF)

ISSN 0947-8620

Abstract

Calculations were performed to define potential evacuation areas in case of a kerosene fire assuming the hypothetical release of large amounts of activation products and tritium. Source terms provided by the PPCS study were used, however, scaled to the amount assumed to be released in such an event. As the amount of dust released for such an event is unknown, parametric studies were performed and a variation of dust source terms and thermal energies were investigated.

Abschätzung von potentiellen Evakuierungsgebieten, die bei einem großen Brand auftreten können

Zusammenfassung

Ziel dieser Arbeiten war die Abschätzung der Größe und Ausdehnung von potentiellen Evakuierungsgebieten bei hypothetischen Freisetzungen von Aktivierungsprodukten und Tritium im Falle eines großen Brandes in und um eine Fusionsanlage. Aktuelle Quellterme der PPCS Studie für Freisetzungen von aktiviertem Staub wurden zu diesem Zwecke benutzt. Da weder die Höhe des Quellterms noch die Stärke des Feuers für einen solchen Fall genau bekannt sind, wurden beide Parameter in den Rechnungen variiert.

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1 Introduction

The aim of these calculations is to define potential evacuation areas in case of a kerosene fire hypothetically assuming the release of large amounts of activation products and tritium. Source terms provided by the PPCS study were used, however, scaled to the amount assumed to be released in such an event. As the amount of dust released for such an event is unknown, parametric studies were performed and a variation of dust source terms were investigated. Similar uncertain is the amount of energy, which will become available when the kerosene is burning down. Therefore, thermal energies were also varied in the calculations.

The main aim of the assessment is the identification of potential early emergency actions following such an event. Therefore, only one type of dose has been used, defining the intervention level for evacuation.

- Evacuation: early dose; sum of external and committed internal effective doses (cloudshine, 7 days integration time for groundshine, 50 years committed dose from inhalation)

In addition, other doses are calculated for comparison reasons for single scenarios, but were not discussed in detail in the report. In particular the total dose with and without ingestion is provided to show the dependency of the individual exposure pathways to the dose. However, the ingestion dose is not part of the evacuation criteria in any country, therefore these calculations were limited to one scenario.

For better comparability of the results, the scale of all figures is identical, independent on the values presented. This allows with one view to see the differences, even if the exact number might be hardly recognised. To overcome this problem, all results are also presented in tables in the Appendix.

2 Release scenarios

Two different release scenarios, one representing a worst case scenario, the other average release conditions, were taken from assessments performed earlier in the frame of the ITER study /RAS01/. The first scenario (category F and low wind speed) is dominating a release at ground level whereas set two (category D and moderate wind speed) represents average weather without rain. The initial release is assumed to be close to the ground level as these cases result in the most severe consequences in the near range of the release point.

Dependent on the severity of the fire, thermal energy is present and can result in the rise of the plume above ground level. As the amount of energy released is unclear, five scenarios were investigated (no thermal power, 1 MW, 10 MW, 50 MW and 100 MW). Reports on the assessment of environmental impact of German intermediate nuclear storage facilities indicate a thermal energy from large kerosene fires in the order of 100 MW /UBA02/.

Acronym	Dispersion parameter	Release height (m)	Weather conditions	Rain	Thermal energy
A_NU_M_10_F_n	MOL	10	F, 0.4 m/s	No	No
A_NU_M_10_F_n_1	MOL	10	F, 0.4 m/s	No	1 MW
A_NU_M_10_F_n_10	MOL	10	F, 0.4 m/s	No	10 MW
A_NU_M_10_F_n_50	MOL	10	F, 0.4 m/s	No	50 MW
A_NU_M_10_F_n_100	MOL	10	F, 0.4 m/s	No	100 MW
A_NU_M_10_D_n	MOL	10	D, 4 m/s	No	No
A_NU_M_10_D_1	MOL	10	D, 4 m/s	No	1 MW
A_NU_M_10_D_50	MOL	10	D, 4 m/s	No	10 MW
A_NU_M_10_D_10	MOL	10	D, 4 m/s	No	50 MW
A_NU_M_10_D_100	MOL	10	D, 4 m/s	No	100 MW

Table 1: Definition of the release scenarios for accidental releases (NU defines the source term)

2.1 Source terms

As representative for the release of activation products, the dust source term from the plant concept A of the PPCS study was used. This source term is defined for the release of 35 g and is presented in Table 2. Only the most significant nuclides were selected out of about 1200 provided by /HAN03/. This source term is also provided by /DIP03/.

For this dust source term, a parameter study was performed for both the worst case and the average release conditions. The dust source term was scaled from 0.1 kg to 100 kg.

NO.	NUCLIDE	SUM	
4	NA- 24	.17130E+10	.
6	P - 32	.17500E+10	.
11	SC- 46	.45070E+10	.
13	SC- 48	.32270E+10	.
16	CR- 51	.16380E+13	.
17	MN- 52M	.14230E+10	.
18	MN- 52	.66470E+10	.
20	MN- 54	.17490E+13	.
21	MN- 56	.61660E+13	.
23	FE- 55	.13100E+14	.
24	FE- 59	.33030E+11	.
28	CO- 58M	.17460E+10	.
29	CO- 58	.16290E+10	.
30	CO- 60M	.17370E+11	.
31	CO- 60	.13180E+11	.
47	RB- 86	.11900E+10	.
92	SB-124	.97460E+10	.
132	BA-140	.22390E+07	.
133	LA-140	.12150E+10	.
153	HF-181	.26210E+10	.
157	TA-182	.17400E+12	.
158	TA-183	.66630E+12	.
159	W -181	.12520E+13	.
161	W -185	.65660E+13	.
162	W -187	.28280E+14	.
163	RE-184M	.35860E+10	.
164	RE-184	.33570E+11	.
166	RE-186	.53190E+13	.
167	RE-188M	.38680E+12	.
168	RE-188	.14200E+14	.

Table 2: Activation product source term (PMA Dust, 35 g)

The second source term contains only tritium in HTO form. Here, it was assumed that 1 kg (3.7E+17 Bq) was released.

2.2 Input parameters

The following Table defines the most important input parameters for the calculations. Only potential doses with shielding factors of 1.0 were applied. The parameters were selected similar to those used in previous calculations.

parameter	value
source term	Activation products and HTO
individual dose for the	Most Exposed Individual
release height (accidental)	10 m (plume rise with fire)
building dimensions (h x w)	56 x 80
release duration	1 hr
washout coefficient (w)	w = A*I**B (1/s)
with rain intensity I	in mm/hr (here 1 mm/hr)
coefficient A (nobel gas)	0.0 (hr s/mm)
coefficient B (nobel gas)	0.0
coefficient A (aerosol)	8.0 E-05 (hr s/mm)
coefficient B (aerosol)	0.8
coefficient A (HT)	0.0 (hr s/mm)
coefficient B (HT)	0.0
coefficient A (HTO)	9.0 E-05 (hr s/mm)
coefficient B (HTO)	0.6
deposition velocity (nobel gas)	0.0 m/s
deposition velocity (aerosol)	0.001 m/s
deposition velocity (HTO, routine)	0.005 m/s
deposition velocity (HTO, accidental)	variable
dose conversion factors act. prod.	Nuclide dependent
dose conversion factor inhalation HT	6.8 E-16 Sv/Bq
dose conversion factor inhalation HTO	1.6 E-11 Sv/Bq
dose conversion factor ingestion HTO	1.6 E-11 Sv/Bq
dose conversion factor ingestion OBT	4.0 E-11 Sv/Bq
breathing rate	2.66 E-4 m**3/s
skin absorption rate (HTO)	1.60 E-4 m**3/s
shielding factor	1.0 (potential doses)
shielding factor	1.0 (protective measures)

Table 3: Input parameters for the calculations

2.3 Calculation of areas and distances

When calculating the areas and distances, one has to have in mind that the computer codes are calculating for discrete grid points. In this case 20 radial distance bands and 72 sectors build the result area for the models. Its representative grid point and a given lower and the upper radius define an area in one of the 72 sectors. To determine the maximum distance, first the grid point, which exceeds the dose, is taken and if necessary interpolation between two points is performed. Interpolation is performed in a way that the distance between two radii is subdivided into three intervals and if the dose value is fallen into one of these intervals, the mid point of the interval is taken. COSYMA uses a virtually logarithmic scaling with distance. This is for example 20 km, 32 km and 46 km in the region where the overall maximum distance and area is calculated. The grid point at 32 km represents an area, which ranges from 26 km up to 39 km. Only when the dose at such a representing grid point exceeds the threshold its representative area is fully taken into account. No interpolation is performed for the area calculation.

3 Results for evacuation criteria

3.1 Worst case release scenario A_NU_M_10_F_n

As pointed out earlier, for dust, a parametric study was performed. Results of all these calculations can be found in the Appendix. In Table 4, results for the most severe, the 100 kg case, are presented. For tritium, only a release of 1 kg was investigated. As can be seen from Table 4, the areas and maximum distances are much lower compared to those, which can result from the release of the 100 kg of dust.

Released quantity in [kg]	Fire	Area outside 1km radius, where … mSv "limit" is exceeded [km2] + maximum distance from release point (km)			
		50 mSv		100 mSv	
		Area	Distance	Area	Distance
1 kg HTO	no	1.9	~5	0.7	~3.2
1 kg HTO	1 MW	0.3	~2	-	-
1 kg HTO	10 MW	-	-	-	-
1 kg HTO	50 MW	-	-	-	-
1 kg HTO	100 MW	-	-	-	-
100 kg Dust	no	71.4	~45	30.8	~25
100 kg Dust	1 MW	69.1	~40	30.7	~22
100 kg Dust	10 MW	30.7	~27	7,3	~13
100 kg Dust	50 MW	10.0	~13	3.7	~4
100 kg Dust	100 MW	2.8	~9	-	-

Table 4: Area and maximum distance of the evacuation zone for the worst case release scenario

It is interesting to note, that the inhalation pathways dominates the dose for the evacuation criteria. For the dust, inhalation contributes to more than 70 % to the early dose. In case of tritium, the contribution from inhalation during the plume passage amounts to more than 80% in the near range but is reverse far away from the source. There, the reemission pathways is dominant, however this effect is the result of the constant wind direction, which is unlikely to occur in reality.

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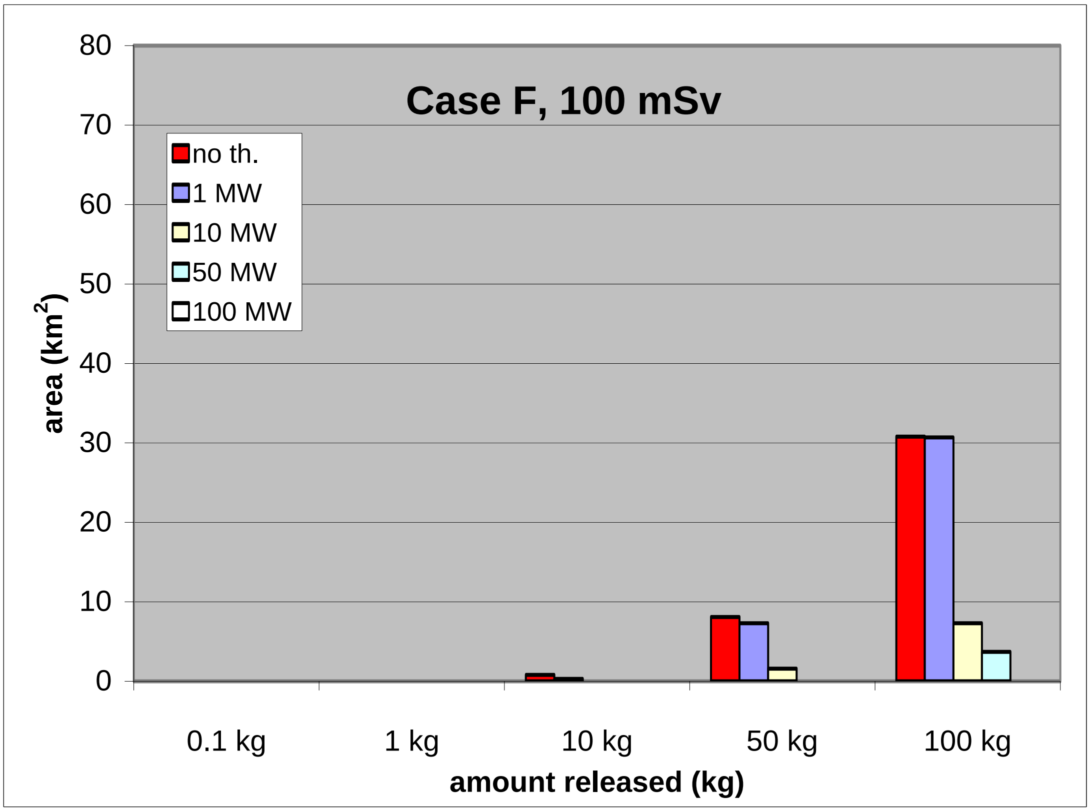
The plume rise due to fires can reduce the dose significantly. A relatively small thermal energy of 1 MW increases the release height to more than 70m, however, due to initial widening of the plume, the concentration at ground level is not reduced significantly. Thermal energies of 10 MW result in plume rise up to 150m, 100 MW enhance the final rise to the mixing layer height, which is in this case 240 m.



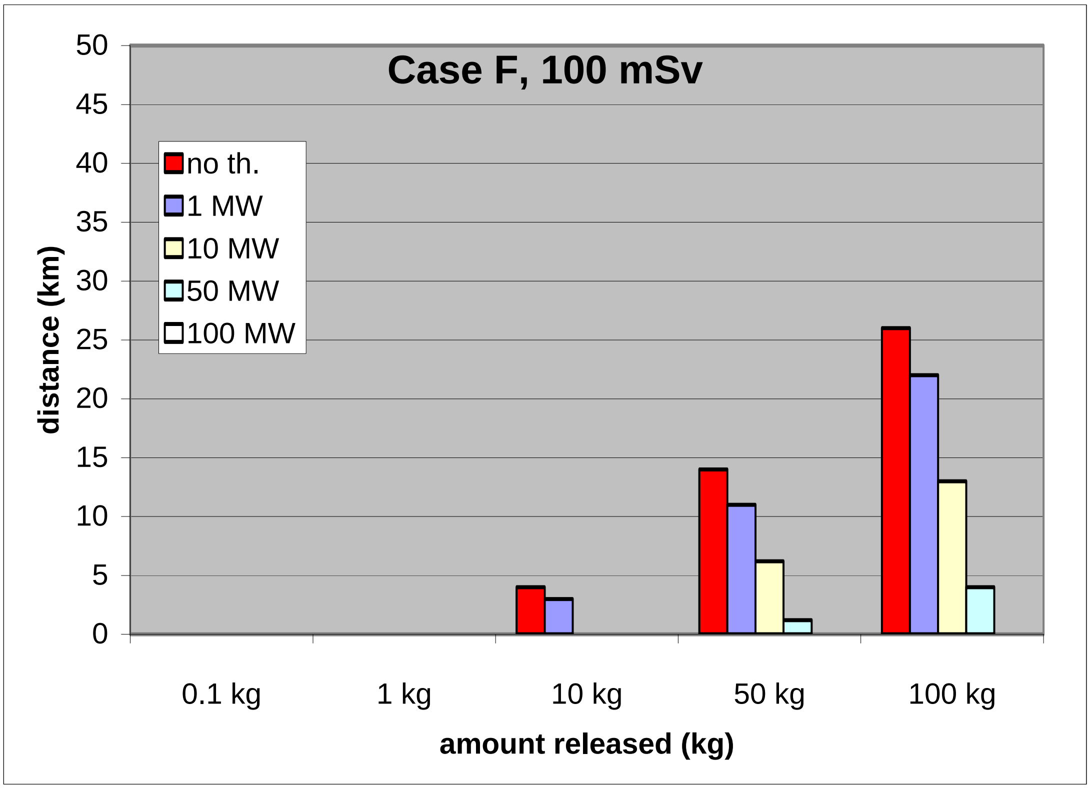
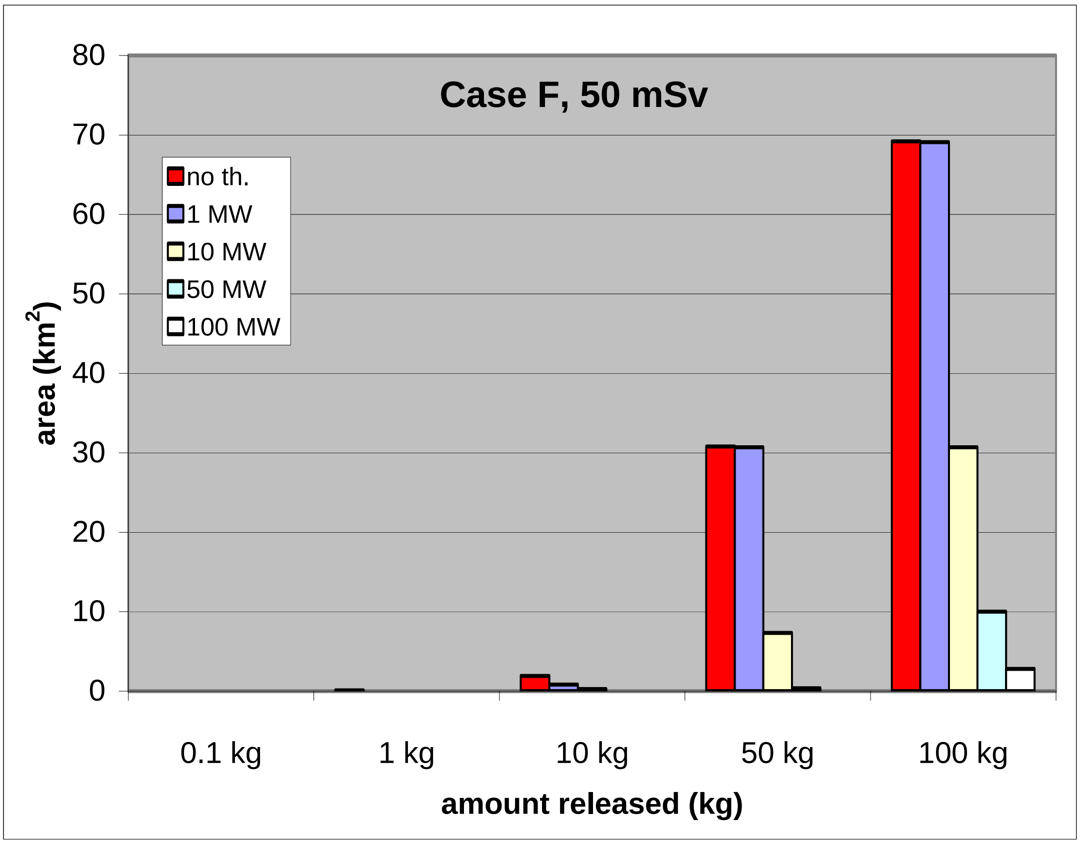


Figure 1 Potential evacuation areas (top) for a dust release and its maximum distance (bottom) under the assumption of an intervention level of 100 mSv (worst case)

Figure 1 shows that area and distance are highest for 100 kg case and no thermal energy involved. As soon as thermal energy is present, the total area and the maximum distance of the intervention reduces. In case of the 100 kg released, the area reduces from about 30 km^2 to zero when the energy increases from zero to 100 MW. It can also be observed that below 1 kg no potential intervention is necessary.



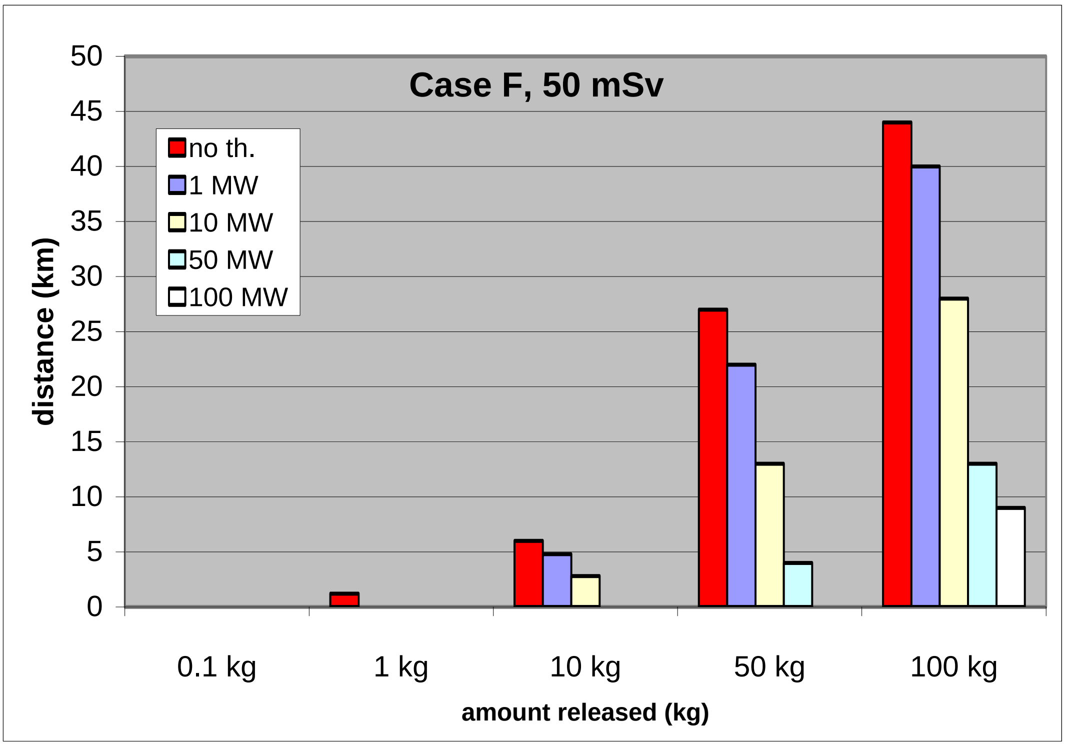


Figure 2 Potential evacuation areas (top) for a dust release and its maximum distance (bottom) under the assumption of an intervention level of 50 mSv (worst case)

When setting the intervention level for evacuation to 50 mSv, the areas will be more than two times larger whereas the maximum distance is about two times larger. The very small difference between the maximum distances for the two cases without thermal energy and with 1 MW is related to the fact that only discrete points are used for the calculations (see also chapter 2.3).

Areas and maximum distances are for tritium only one tenth of that of the corresponding area for dusts. Areas do not exceed 2 km^2 and distances reach up to 5 km.

3.2 Average release scenario A_NU_M_10_D_n

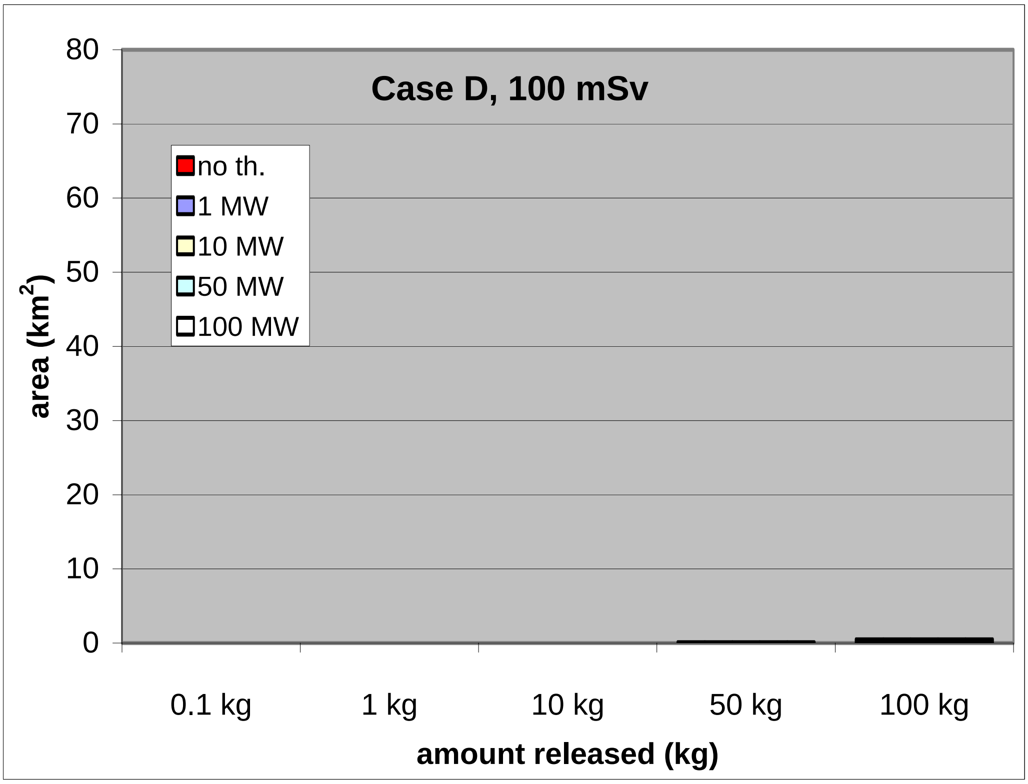
Similar to the worst case scenario, the results of the parametric study for dust can be found in the Appendix. In Table 5, results for the 1 kg HTO and 100 kg dust case are presented.

Released quantity in [kg]	Fire	Area outside 1km radius, where … mSv "limit" is exceeded [km2] + maximum distance from release point (km)			
		50 mSv		100 mSv	
		Area	Distance	Area	Distance
1 kg HTO	no	-	-	-	-
1 kg HTO	1 MW	-	-	-	-
1 kg HTO	10 MW	-	-	-	-
1 kg HTO	50 MW	-	-	-	-
1 kg HTO	100 MW	-	-	-	-
100 kg Dust	no	1.2	~4	0.5	~2.5
100 kg Dust	1 MW	1.2	~4	0.5	~2.5
100 kg Dust	10 MW	1.2	~4	0.5	~2.5
100 kg Dust	50 MW	1.2	~4	0.5	~2.5
100 kg Dust	100 MW	1.2	~4	0.5	~2.5

Table 5: Area and maximum distance of the evacuation zone for the average release scenario

The importance of the inhalation dose is similar in this scenario. Doses with thermal energies shown in Table 5 do not differ as the thermal rise is constrained by building wake effects. Only energies beyond 140 Mw result in plume rise effects with an effective release height of several hundreds of meters. In general, all areas and distances for the potential evacuation measure are much lower compared to the worst case release scenario. The higher wind speed and the increased turbulence compared to the stable release conditions are the two decisive factors determining the potential intervention areas and maximum distances.

The maximum distances and areas are zero for tritium. As for dust, the dispersion characteristics with an increased turbulence and higher wind speed force the dose values below the given intervention criteria.



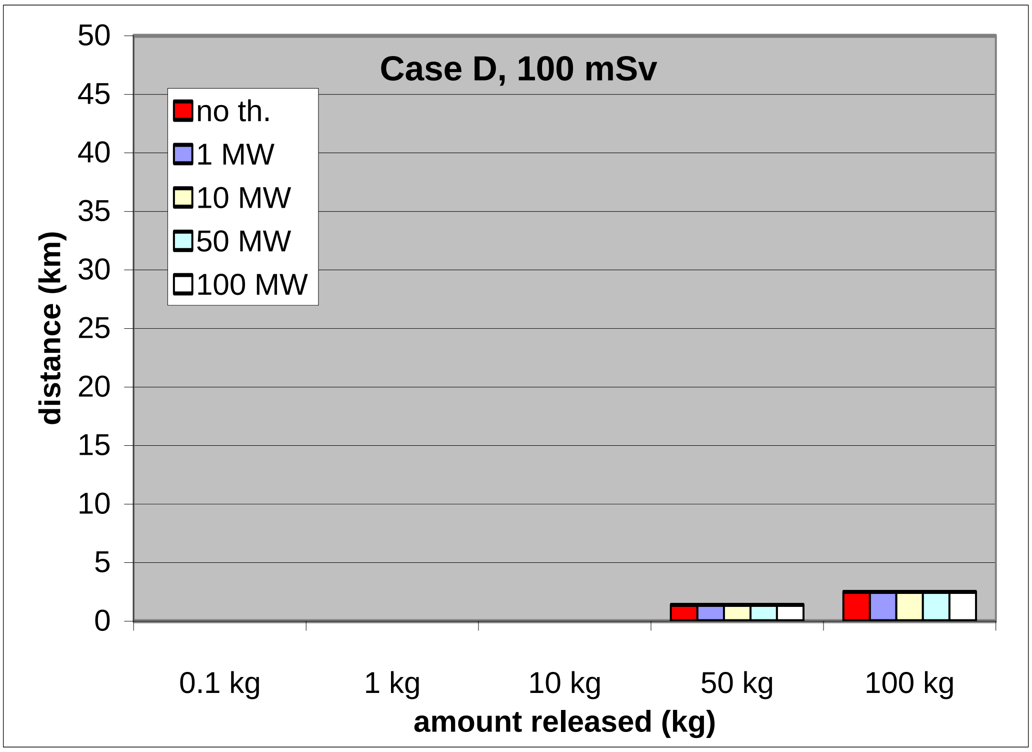
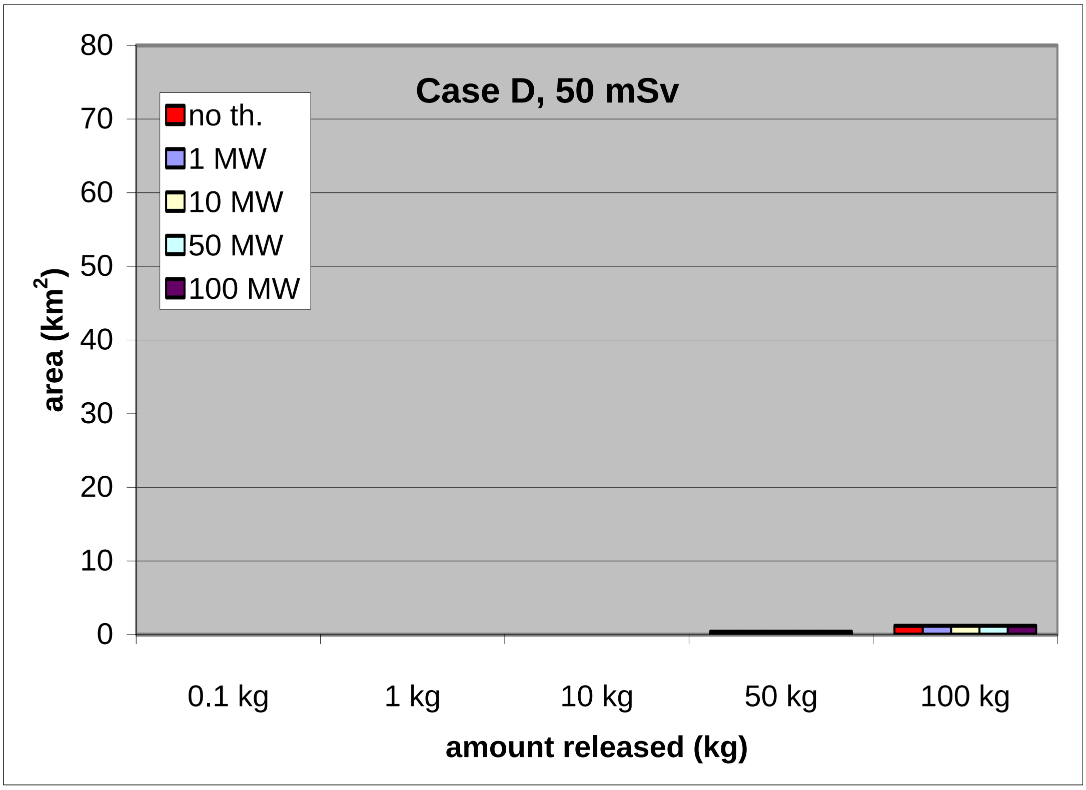


Figure 3 Potential evacuation areas (top) for a dust release and its maximum distance (bottom) under the assumption of an intervention level of 100 mSv (average weather)



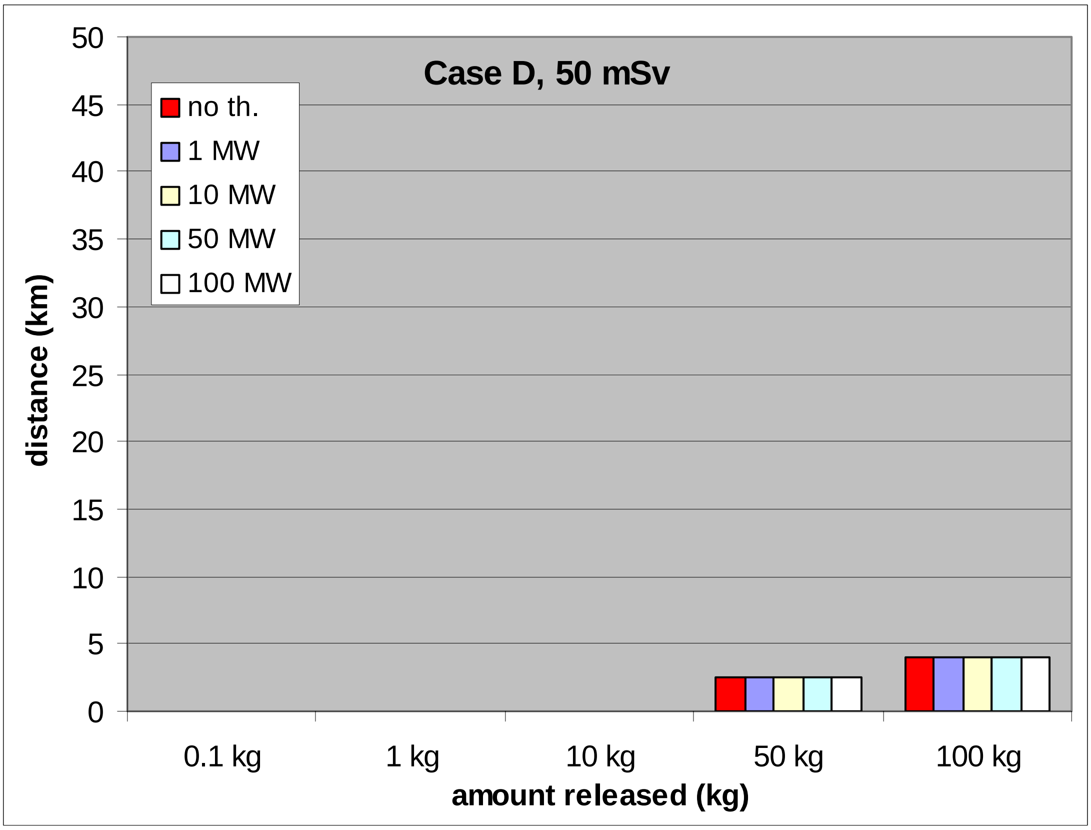


Figure 4 Potential evacuation areas (top) for a dust release and its maximum distance (bottom) under the assumption of an intervention level of 50 mSv (average weather)

3.3 Discussion of the worst case release scenarios

The threshold source term for initiating evacuation assuming the 50 mSv criteria can be estimated to 770 g of dust. No evacuation is required when the dust source term is lower. The dependencies of the area and the maximum distance on the source term and the thermal energy are shown for the worst case conditions in Figure 5 and Figure 6, respectively. Worst case conditions for the source term variation are no thermal energy and weather of category F whereas the 100 kg dust scenario with worst case weather is used for the energy dependency.

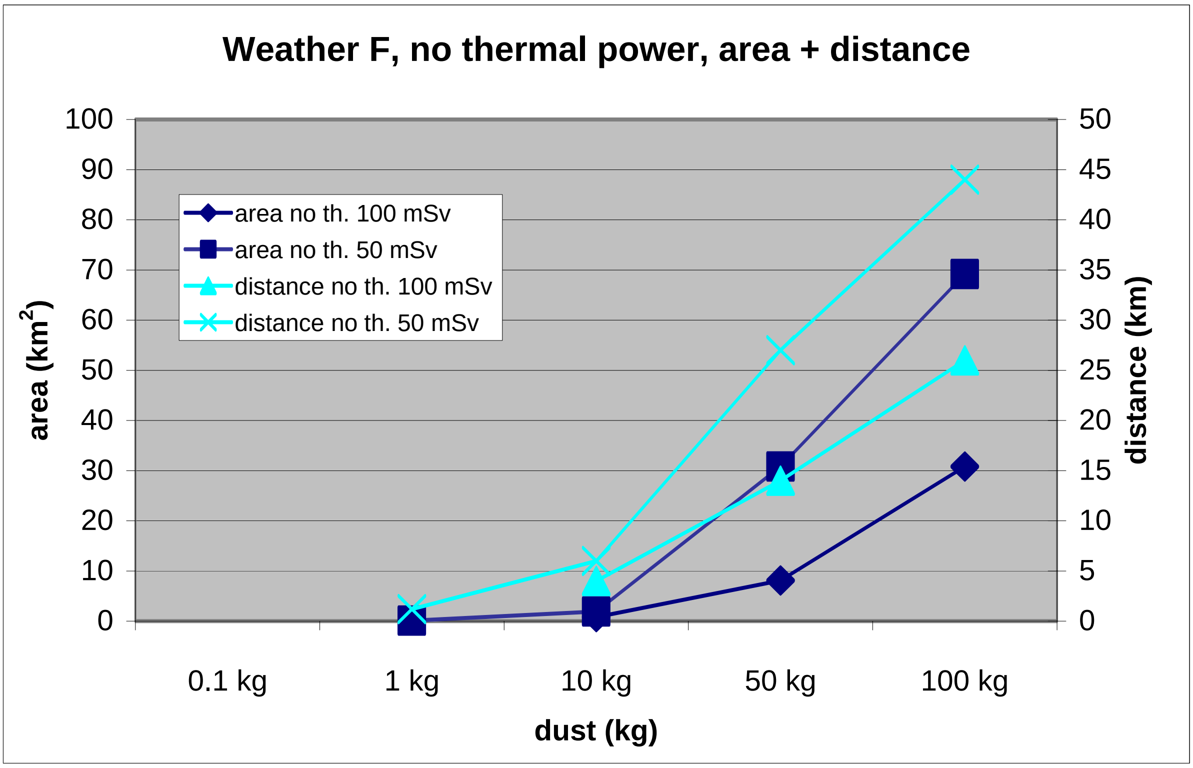


Figure 5 Source term dependency of the potential evacuation areas for dust and the maximum distance for worst case conditions (no thermal energy, category F)

Up to a release of 10 kg of dust, the area and maximum distance increase slowly. From 10 to 100 kg, the curve rises nearly linear (see Figure 5). Only the values for 50 kg lay slightly below the linear extrapolation. As pointed out earlier, this might be the result of the grid calculations, which is used in COSYMA. Only those points, which exceed the threshold values, are taken with their representative areas.

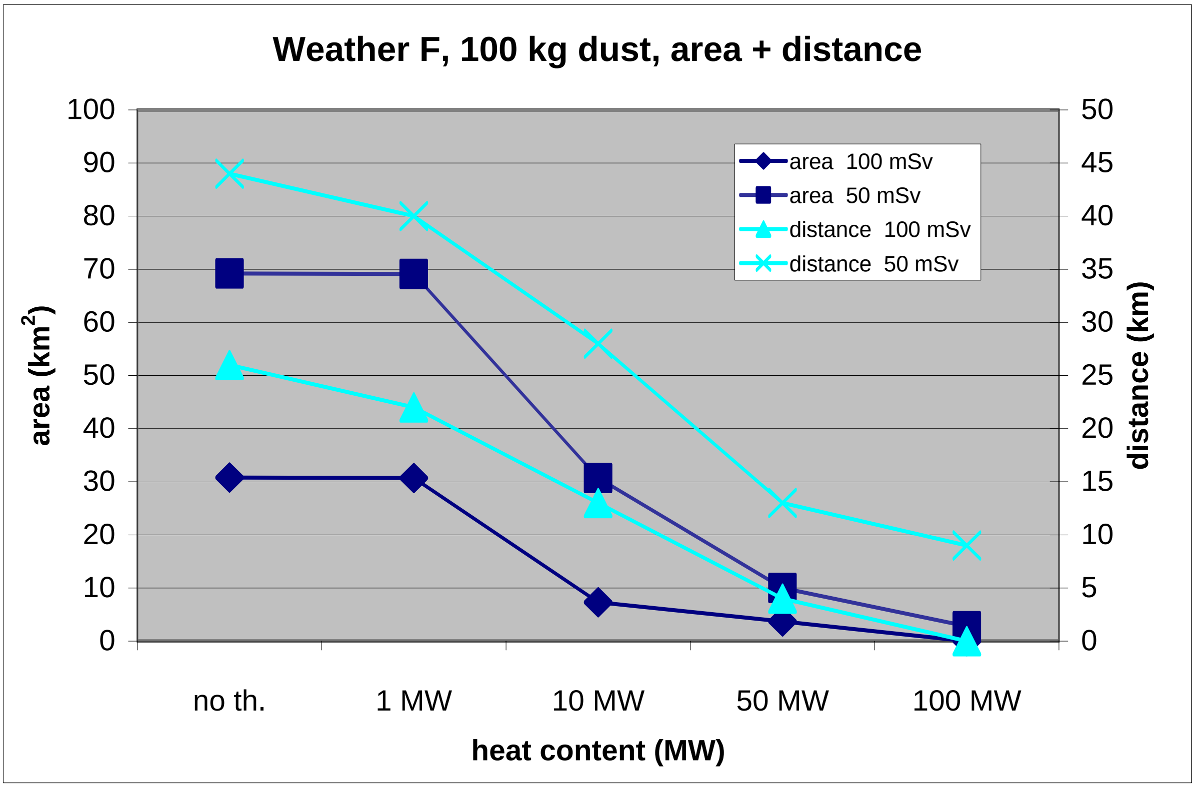


Figure 6 Energy dependency of the potential evacuation areas for dust and the maximum distance for worst case conditions (100 kg dust category F)

Highest values for the potential evacuation and maximum distance are obtained without any thermal energy involved. Between no thermal energy and the energy of 1 MW nearly one decrease in the affected area is calculated. This can be explained partly with the extend of the grid areas at these distance bands as explained in chapter 2.3. From 1 MW to 50 MW, the dependency is nearly linear whereas the steepness slows down towards 100 MW. With this energy, the plume rises up to the mixing layer height and therefore the ground level contamination is rather low in the near range.

Dependencies for tritium are similar to dust, except that the dose values are much smaller (see Figure 7). The areas and distances would only increase by about 10% when combining the highest dust and tritium source terms (100 kg dust and 1 kg tritium). This value is fictitious, as the dose value calculated would not exceed the threshold at a distance band further down from the release point.

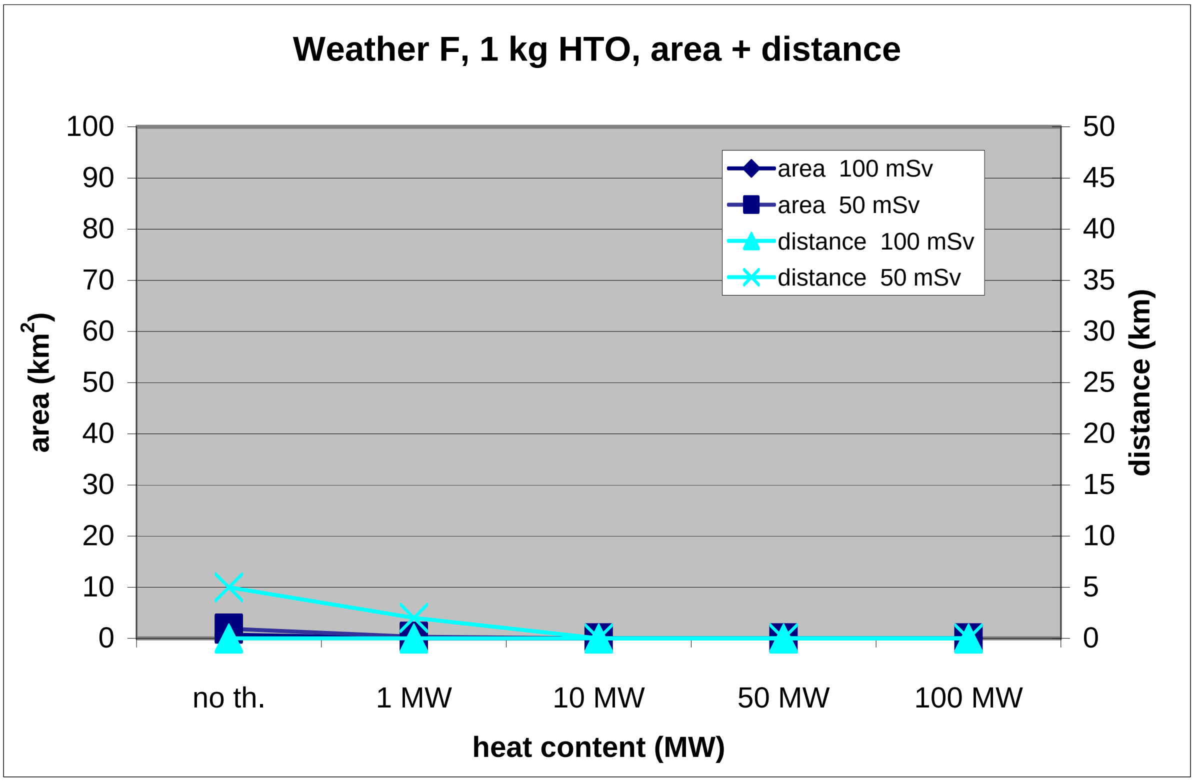


Figure 7 Energy dependency of the potential evacuation areas for tritium releases and the maximum distance for the worst case conditions (1 kg HTO, category F)

4 Results for the potential dose

The potential dose is calculated for the worst case release scenario without plume rise and the dust source term of 100 kg. Ingestion rates as used in other ITER studies were applied. The total doses are at least 10 times higher compared to the early dose of the evacuation criteria.

distance (km)	early dose (Sv)	EDE with ingestion (Sv)
0.145	3.0E+01	4.0E+02
0.18	2.7E+01	3.7E+02
0.32	2.0E+01	2.5E+02
0.5	1.4E+01	1.8E+02
0.68	1.0E+01	1.3E+02
1	6.4E+00	8.2E+01
1.5	3.7E+00	4.8E+01
2	2.5E+00	3.1E+01
3.2	1.3E+00	1.6E+01
5	6.3E-01	8.2E+00
6.8	4.0E-01	5.4E+00
10	2.8E-01	3.7E+00
15	1.8E-01	2.6E+00
20	1.4E-01	2.0E+00
32	7.6E-02	1.2E+00
50	4.0E-02	6.8E-01
68	2.4E-02	4.5E-01
100	1.1E-02	2.4E-01

Table 6: Comparison of the early dose and chronic EDE for the dust source term and worst case release scenario, no plume rise

A typical example for the contribution of pathways is exemplarily shown for the 10 km distance:

```
CL %    GR %    IH %    IG %    IHR%
0.78   25.07    5.47   68.68    0.00
```

The ingestion pathways dominate the dose and external exposure from ground is second. Ignoring ingestion, the dose would be lower by about 70 %. This factor is roughly applicable over the total distance range. Thus the long term dose without ingestion is about 3 to 4 times higher than the early dose. Doses without ingestion are important for the long term actions, however not considered in these investigations.

5 References

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6 Appendix

6.1 Worst case release scenario for dust source term

6.1.1 Intervention level 100 mSv, potential area

Released quantity Thermal energy	0.1 kg	1 kg	10 kg	50 kg	100 kg
no th.			0.8	8.1	30.8
1 MW			0.3	7.3	30.7
10 MW				1.6	7.3
50 MW					3.7
100 MW					0

Table 7: Area (km^2) of the potential evacuation zone for the worst case release scenario and an intervention criteria of 100 mSv

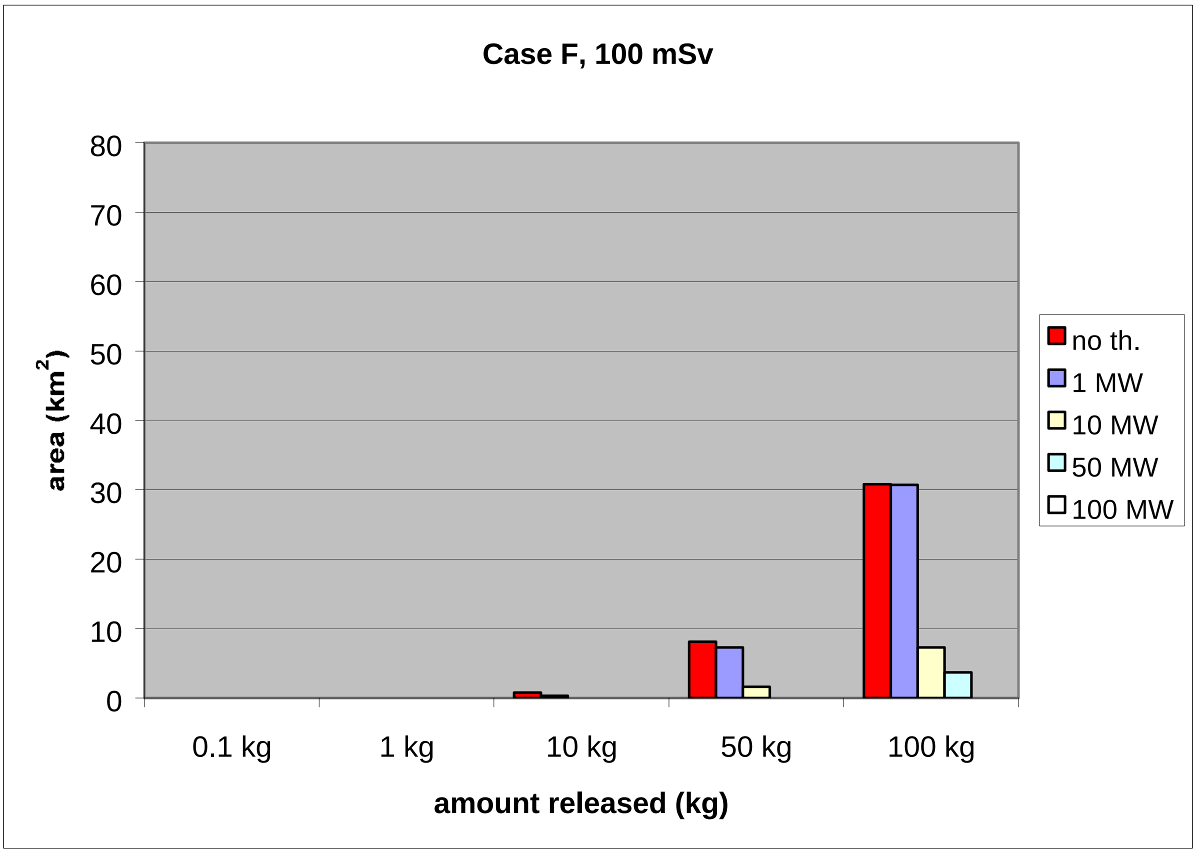

Figure 8: Potential intervention area (km^2) (worst case scenario, 100 mSv intervention criteria)

6.1.2 Intervention level 100 mSv, maximum distance

Released quantity Thermal energy	0.1 kg	1 kg	10 kg	50 kg	100 kg
no th.			4	14	26
1 MW			3	11	22
10 MW				6.2	13
50 MW				1.2	4
100 MW					0

Table 8: Maximum distance (km) of the potential evacuation zone for the worst case release scenario and an intervention criteria of 100 mSv

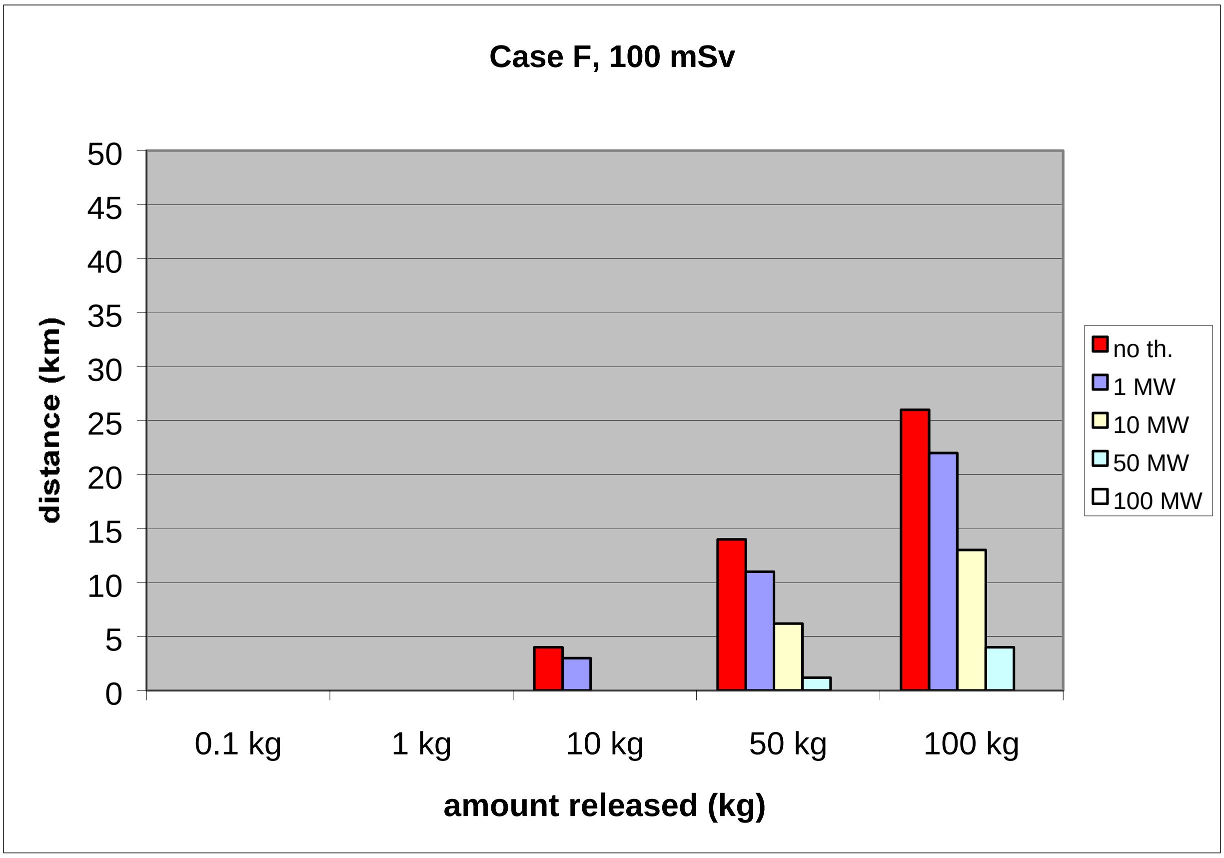

Figure 9: Potential maximum distance of intervention (km) (worst case scenario, 100 mSv intervention criteria)

6.1.3 Intervention level 50 mSv, potential area

Released quantity Thermal energy	0.1 kg	1 kg	10 kg	50 kg	100 kg
no th.		0.1	1.9	30.8	69.2
1 MW			0.8	30.7	69.1
10 MW			0.3	7.3	30.7
50 MW				0.4	10
100 MW					02.8

Table 9: Area (km^2) of the potential evacuation zone for the worst case release scenario and an intervention criteria of 50 mSv

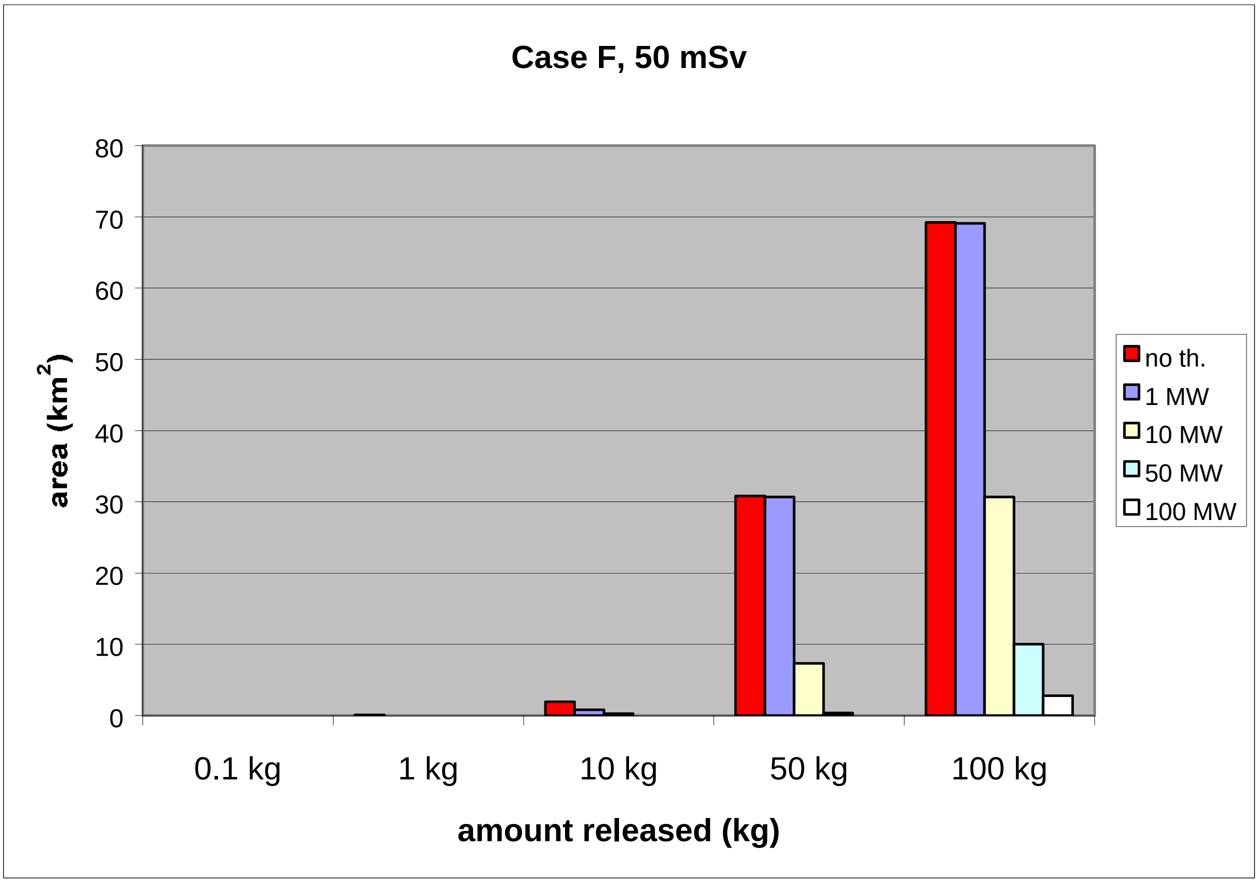

Figure 10: Potential intervention area (km^2) (worst case scenario, 50 mSv intervention criteria)

6.1.4 Intervention level 50 mSv, maximum distance

Released quantity Thermal energy	0.1 kg	1 kg	10 kg	50 kg	100 kg
no th.		1.2	6	27	44
1 MW			4.8	22	40
10 MW			2.8	13	28
50 MW				4	13
100 MW					

Table 10: Maximum distance (km) of the potential evacuation zone for the worst case release scenario and an intervention criteria of 50 mSv

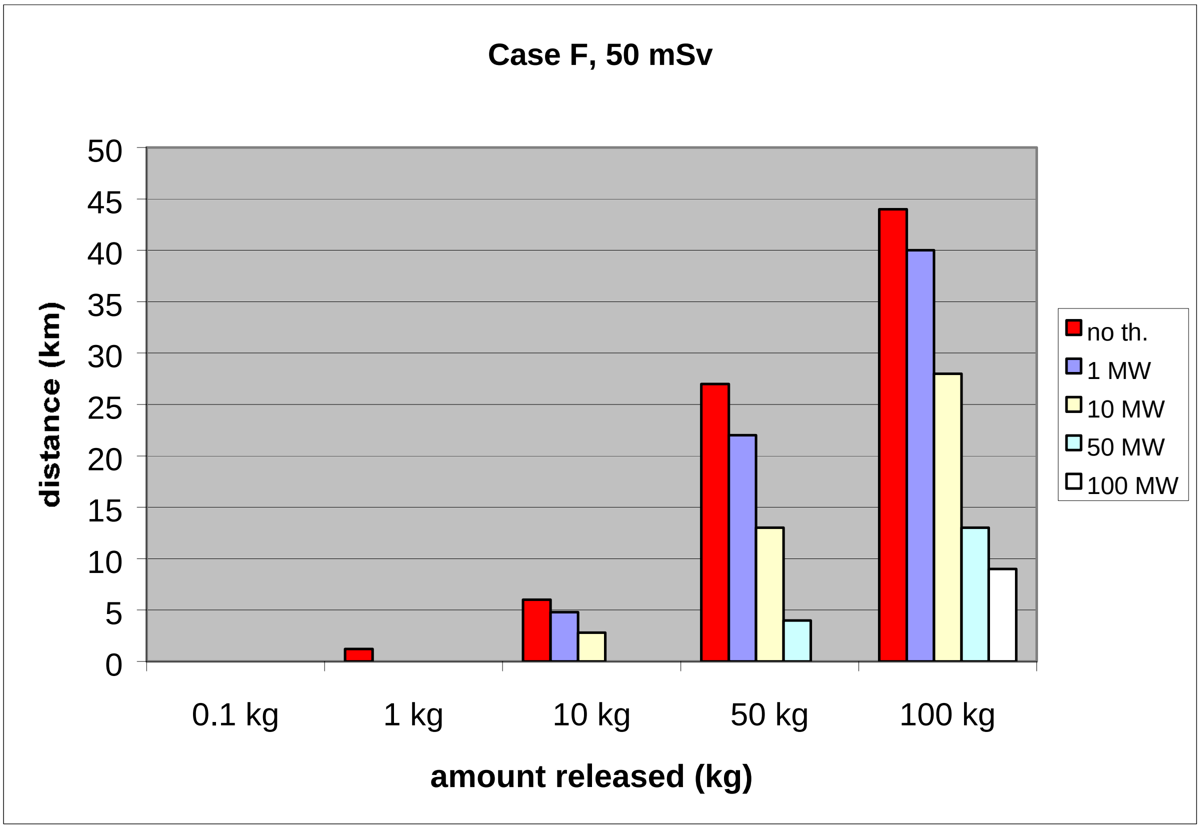

Figure 11: Potential maximum distance of intervention (km) (worst case scenario, 50 mSv intervention criteria)

6.1.5 Contribution of pathways to the dose from a dust source term (100 kg, category F)

I	R(I), KM	CL %	GR %	IH %	early dose (SV)
1	.145	1.311	21.486	77.203	.29815E+02
2	.180	1.652	21.410	76.939	.27459E+02
3	.320	2.565	21.202	76.233	.19830E+02
4	.500	3.316	21.028	75.656	.13680E+02
5	.680	3.887	20.893	75.220	.99964E+01
6	1.000	4.661	20.707	74.632	.63645E+01
7	1.500	5.568	20.484	73.949	.37428E+01
8	2.000	6.394	20.289	73.317	.25138E+01
9	3.200	7.504	19.984	72.512	.12517E+01
10	5.000	8.802	19.634	71.564	.62966E+00
11	6.800	9.304	19.466	71.230	.40335E+00
12	10.000	10.117	19.228	70.655	.28162E+00
13	15.000	9.636	19.202	71.162	.18298E+00
14	20.000	9.549	19.144	71.307	.13501E+00
15	32.000	5.825	19.705	74.470	.75859E-01
16	50.000	5.263	19.474	75.262	.39819E-01
17	68.000	4.763	19.231	76.006	.23738E-01
18	100.000	3.994	18.845	77.161	.11127E-01

Contribution of pathways to the dose from tritium source term

DISTANCE (M)	CL %	GR %	IH %	IG %	IHR %	EARLY D. (SV)
145.0	0.00	0.00	99.05	0.00	0.95	2.39E+00
180.0	0.00	0.00	96.44	0.00	3.56	2.25E+00
320.0	0.00	0.00	94.45	0.00	5.55	1.64E+00
500.0	0.00	0.00	92.78	0.00	7.22	1.15E+00
680.0	0.00	0.00	91.12	0.00	8.88	8.50E-01
1000.0	0.00	0.00	89.97	0.00	10.03	5.38E-01
1500.0	0.00	0.00	88.41	0.00	11.59	3.17E-01
2000.0	0.00	0.00	86.31	0.00	13.69	2.14E-01
3200.0	0.00	0.00	84.86	0.00	15.14	1.07E-01
4600.0	0.00	0.00	82.36	0.00	17.64	6.25E-02
6800.0	0.00	0.00	80.43	0.00	19.57	3.57E-02
10000.0	0.00	0.00	78.44	0.00	21.56	2.51E-02
15000.0	0.00	0.00	74.75	0.00	25.25	1.70E-02
20000.0	0.00	0.00	70.60	0.00	29.40	1.30E-02
32000.0	0.00	0.00	64.84	0.00	35.16	7.40E-03
46000.0	0.00	0.00	55.73	0.00	44.27	4.77E-03
68000.0	0.00	0.00	44.27	0.00	55.73	2.72E-03
100000.0	0.00	0.00	23.10	0.00	76.90	1.27E-03

6.2 Average release scenario for dust source term

6.2.1 Intervention level 100 mSv, potential area

Released quantity Thermal energy	0.1 kg	1 kg	10 kg	50 kg	100 kg
no th.				0.1	0.5
1 MW				0.1	0.5
10 MW				0.1	0.5
50 MW				0.1	0.5
100 MW				0.1	0.5

Table 11: Area (km^2) of the potential evacuation zone for the average release scenario and an intervention criteria of 100 mSv

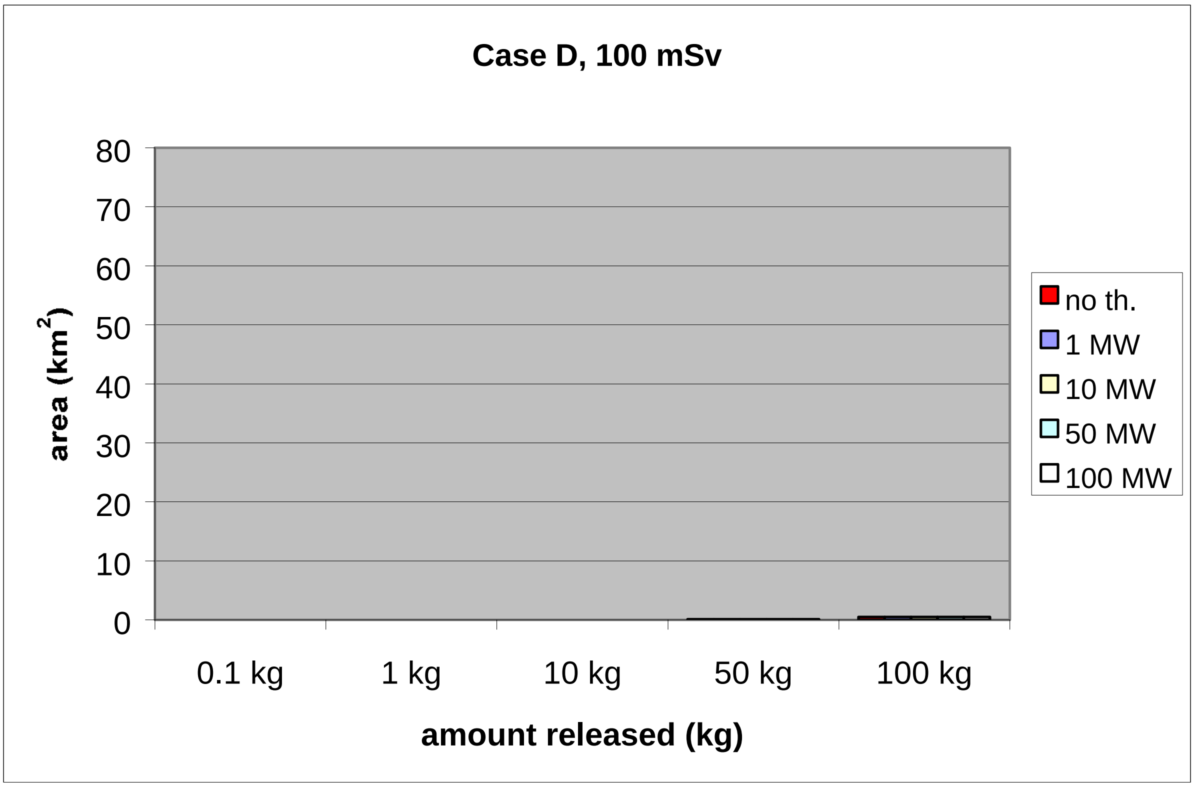

Figure 12: Potential intervention area (km^2) (average weather, 100 mSv intervention criteria)

6.2.2 Intervention level 100 mSv, maximum distance

Released quantity / Thermal energy	0.1 kg	1 kg	10 kg	50 kg	100 kg
no th.				1.4	2.5
1 MW				1.4	2.5
10 MW				1.4	2.5
50 MW				1.4	2.5
100 MW				1.4	2.5

Table 12: Maximum distance (km) of the potential evacuation zone for the average release scenario and an intervention criteria of 100 mSv

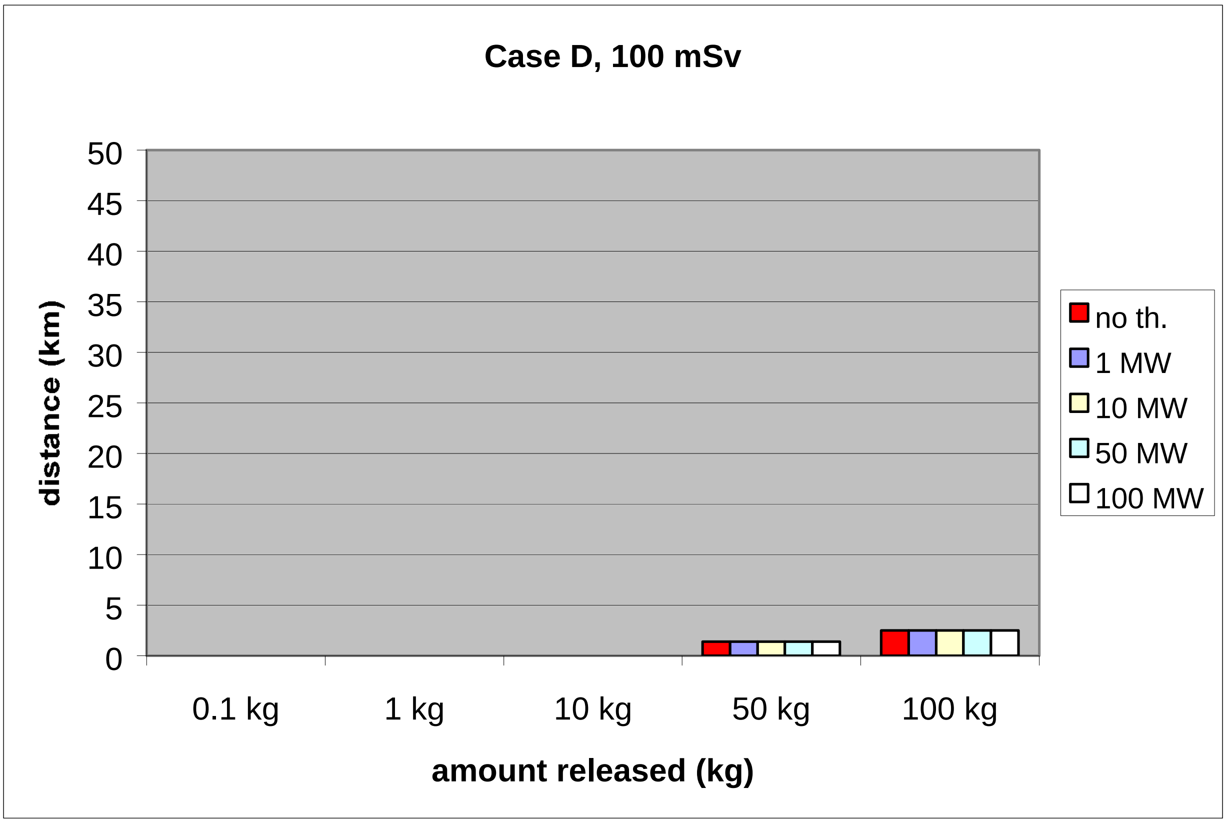

Figure 13: Potential maximum distance of intervention (km) (average weather, 100 mSv intervention criteria)

6.2.3 Intervention level 50 mSv, potential area

Released quantity Thermal energy	0.1 kg	1 kg	10 kg	50 kg	100 kg
no th.				0.4	1.2
1 MW				0.4	1.2
10 MW				0.4	1.2
50 MW				0.4	1.2
100 MW				0.4	1.2

Table 13: Area (km²) of the potential evacuation zone for the average release scenario and an intervention criteria of 50 mSv

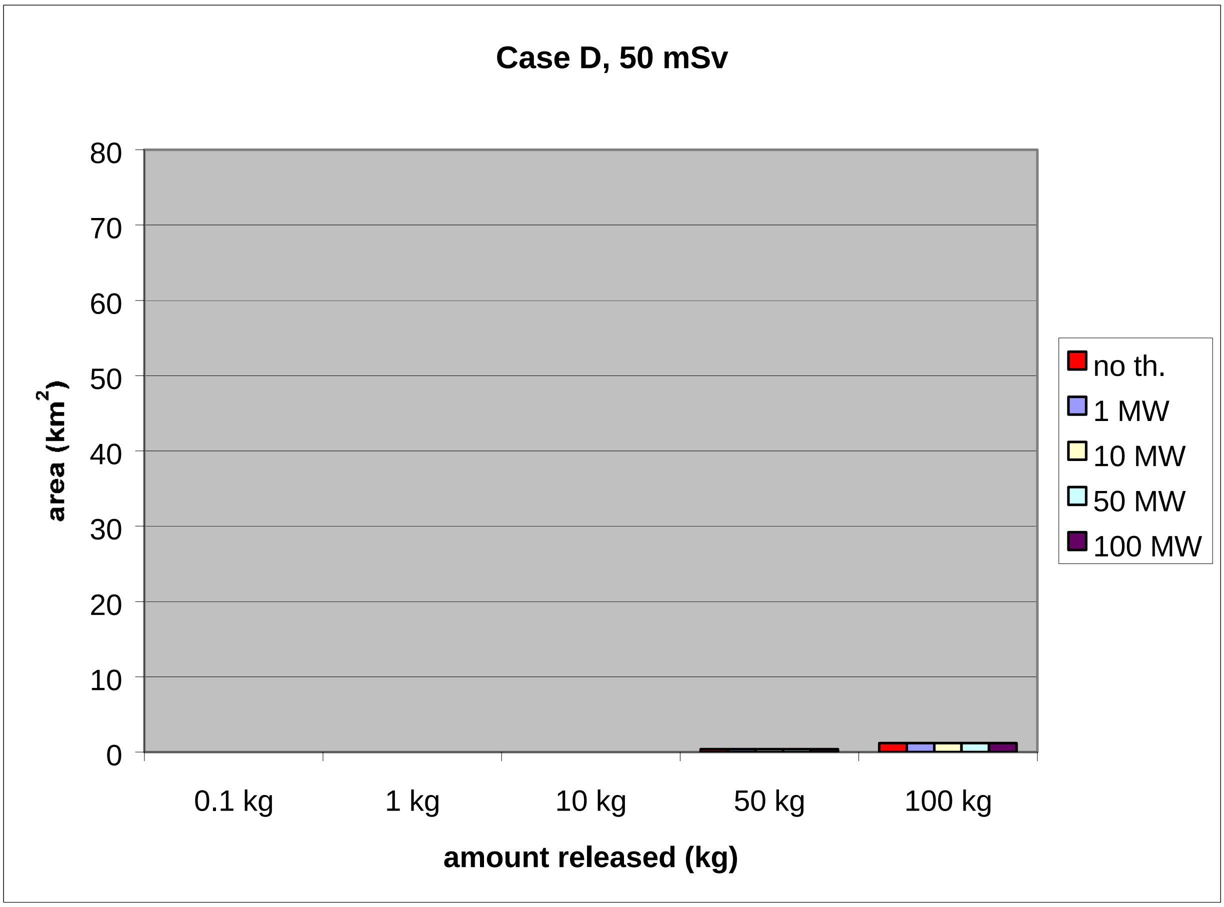

Figure 14: Potential intervention area (km²) (average weather, 50 mSv intervention criteria)

6.2.4 Intervention level 50 mSv, maximum distance

Released quantity Thermal energy	0.1 kg	1 kg	10 kg	50 kg	100 kg
no th.				2.5	4
1 MW				2.5	4
10 MW				2.5	4
50 MW				2.5	4
100 MW				2.5	4

Table 14: Maximum distance (km) of the potential evacuation zone for the average release scenario and an intervention criteria of 50 mSv

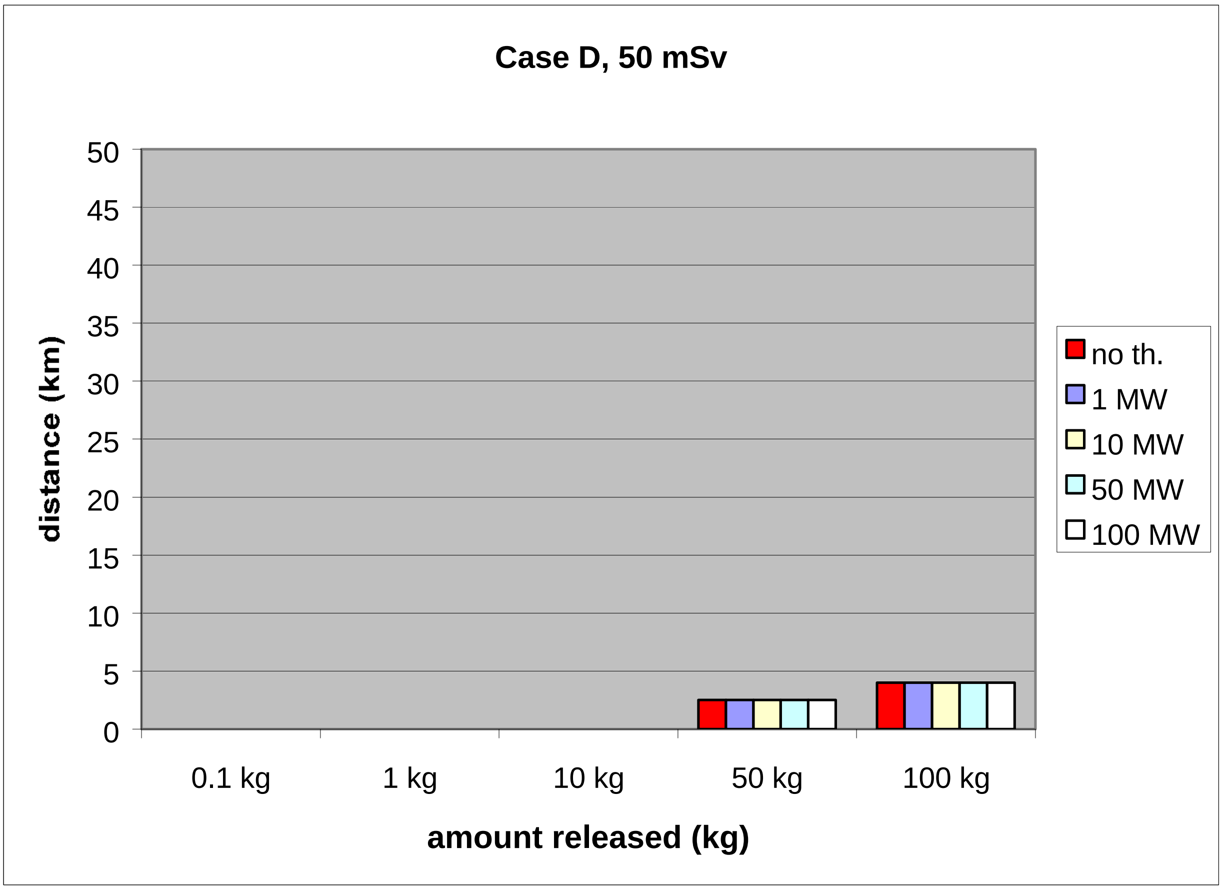

Figure 15: Potential maximum distance of intervention (km) (average weather, 50 mSv intervention criteria)

6.2.5 Contribution of pathways to the dose from a dust source term (100 kg, average)

I	R(I), KM	CL %	GR %	IH %	early dose (SV)
1	.145	2.229	21.294	76.477	.26371E+01
2	.180	2.620	21.208	76.171	.22577E+01
3	.320	3.701	20.972	75.327	.13362E+01
4	.500	4.648	20.764	74.588	.80692E+00
5	.680	5.225	20.637	74.138	.54909E+00
6	1.000	6.036	20.458	73.505	.32866E+00
7	1.500	6.794	20.290	72.917	.18659E+00
8	2.000	7.416	20.150	72.433	.12384E+00
9	3.200	8.226	19.966	71.809	.62312E-01
10	5.000	9.081	19.767	71.151	.32257E-01
11	6.800	9.589	19.645	70.766	.20334E-01
12	10.000	10.230	19.485	70.285	.11364E-01
13	15.000	10.852	19.323	69.825	.66315E-02
14	20.000	11.125	19.232	69.643	.52088E-02
15	32.000	8.850	19.677	71.473	.34914E-02
16	50.000	8.246	19.739	72.015	.23797E-02
17	68.000	7.771	19.782	72.446	.18141E-02
18	100.000	7.099	19.826	73.075	.12516E-02

Contribution of pathways to the dose from tritium source term

DISTANCE (M)	CL %	GR %	IH %	IG %	IHR %	EARLY D. (SV)
145.0	0.00	0.00	97.74	0.00	2.26	2.13E-01
180.0	0.00	0.00	88.88	0.00	11.12	2.00E-01
320.0	0.00	0.00	85.73	0.00	14.27	1.21E-01
500.0	0.00	0.00	80.83	0.00	19.17	7.60E-02
680.0	0.00	0.00	76.26	0.00	23.74	5.40E-02
1000.0	0.00	0.00	73.86	0.00	26.14	3.27E-02
1500.0	0.00	0.00	70.83	0.00	29.17	1.89E-02
2000.0	0.00	0.00	66.73	0.00	33.27	1.31E-02
3200.0	0.00	0.00	65.31	0.00	34.69	6.53E-03
4600.0	0.00	0.00	61.58	0.00	38.42	3.95E-03
6800.0	0.00	0.00	58.93	0.00	41.07	2.24E-03
10000.0	0.00	0.00	56.17	0.00	43.83	1.28E-03
15000.0	0.00	0.00	53.13	0.00	46.87	7.73E-04
20000.0	0.00	0.00	49.58	0.00	50.42	6.38E-04
32000.0	0.00	0.00	48.07	0.00	51.93	4.18E-04
46000.0	0.00	0.00	44.99	0.00	55.01	3.09E-04
68000.0	0.00	0.00	43.39	0.00	56.61	2.09E-04
100000.0	0.00	0.00	26.87	0.00	73.13	1.22E-04