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FISSION PRODUCT RELEASE FROM THE MOLTEN RESEARCH REACTOR CORE, FRM-II

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I. Agenda

1. Background for the investigations
2. radiological design basis accident.
3. activity inventory in the fuellement
4 development of the accident
5 radiation exposer in the environment

5.1 design basis accident
5.2 whole core (beyond design)

II. Main aspects

ad 1

- main assumption for realasation of the FRM II-project: minimizing of nuclear risks, political and social acceptance
- safety report and independant expert's reports
- accident analyses

ad 2

- radiogical design basis accident = postulation of 15 (out of 113) plates of the core melting under water
- defect on one plate, influence to the neighbouring plates, safety factor 5 mounts to 15 plates = 13 %
- beyond design accident on request of the licensing body: Melting of the whole core under water

(ref. Fig 1 and 2)

ad 3

- calculation of the relevant fission products in the melt
  (ref Fig 3)

ad 4

- barriers for fission products release
  - fuel - water
  - water - reactor hall
  - reactor hall - environment
- retaining release factors
- fission product release via the ventilation stack
  (ref Fig 4 and 5)

ad 5.1

- radiation exposer design basis accident, doses for organs and effectiv dose far below limiting value of 50 mSv
  (ref Fig 6)

ad 5.2

- core melting under water, building tight, low pressure ventilation system with filters in operation
- effective doses at the plant fence approx. 11 mSv for adults respectively approx. 13 m Sv for children.
- effectiv doses without low pressure ventilation system without filters, building closed, release only by leakages:

  approx 12 mSv adults
  approx. 17 mSv children

Result:

protection measures against emergencies not necessary in this cases, if it can be realized, that the core stays in the pool under water for all circumstances
(ref fig 7 and 8)

III **Figures**

1.) reactor building, + 11,70 m

2.) reactor main pool, Storage pool primary, cooling system

3.) fission product inventory

4.) principle flow sheme for fisssion product

5.) release factors molten core under water

6.) effective doses in mSv for design basis accident

7.) effective dose dependent to the distance, melting of whole core under water, adults

8.) effective dose dependent to the distance , melting of whole core under water, children

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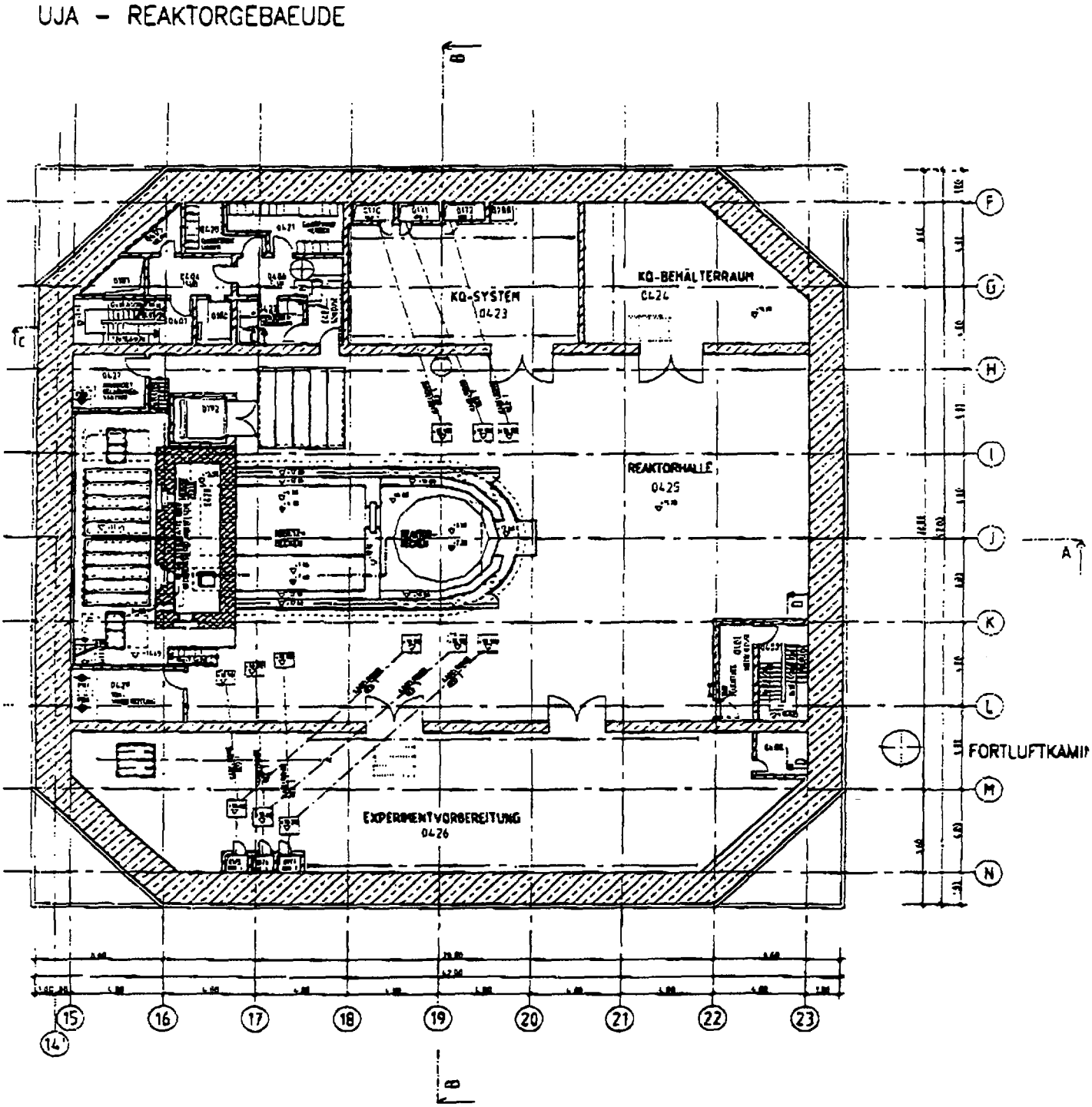

New Munich Research Reactor FRM-II
Reactor Building, Horizontal Section, + 11.70 m **Fig. 1**

fission groups	fission	activity inventy whole core
noble gas	Kr 85	1,47 E + 13 *)
	Kr 85m	7,81 E + 15
	Kr 87	1,58 E + 16
	Kr 88	2,23 E + 16
	Kr 89	2,83 E + 16
	Xe 133	4,11 E + 16
	Xe 133m	1,22 E + 15
	Xe 135	3,89 E + 15
	Xe 135m	6,99 E + 15
	Xe 137	3,67 E + 16
	Xe 138	3,85 E + 16
Halogene	Br 83	3,30 E + 15
	Br 84	6,25 E + 15
	Br 85	7,73 E + 15
	I 131	1,76 E + 16
	I 132	2,69 E + 16
	I 133	4,14 E + 16
	I 134	4,66 E + 16
	I 135	3,85 E + 16
Cäsium/Rubidium	Rb 88	2,25 E + 16
	Rb 89	2,93 E + 16
	Cs 134	2,51 E + 13
	Cs 137	1,20 E + 14
	Cs 138	4,14 E + 16
Tellur/Ruthen	Te 131	1,59 E + 16
	Te 132	2,65 E + 16
	Ru 103	1,14 E + 16
	Ru 106	2,33 E + 14
Strontium	Sr 90	1,15 E + 14
Aktiniden	Pu 238	2,98 E + 10
	Pu 239	2,47 E + 09
	Pu 240	8,44 E + 08
	Cm 242	9,99 E + 07

relevant fission product inventory
20 MW, 50 full powerdays

Fig. 3

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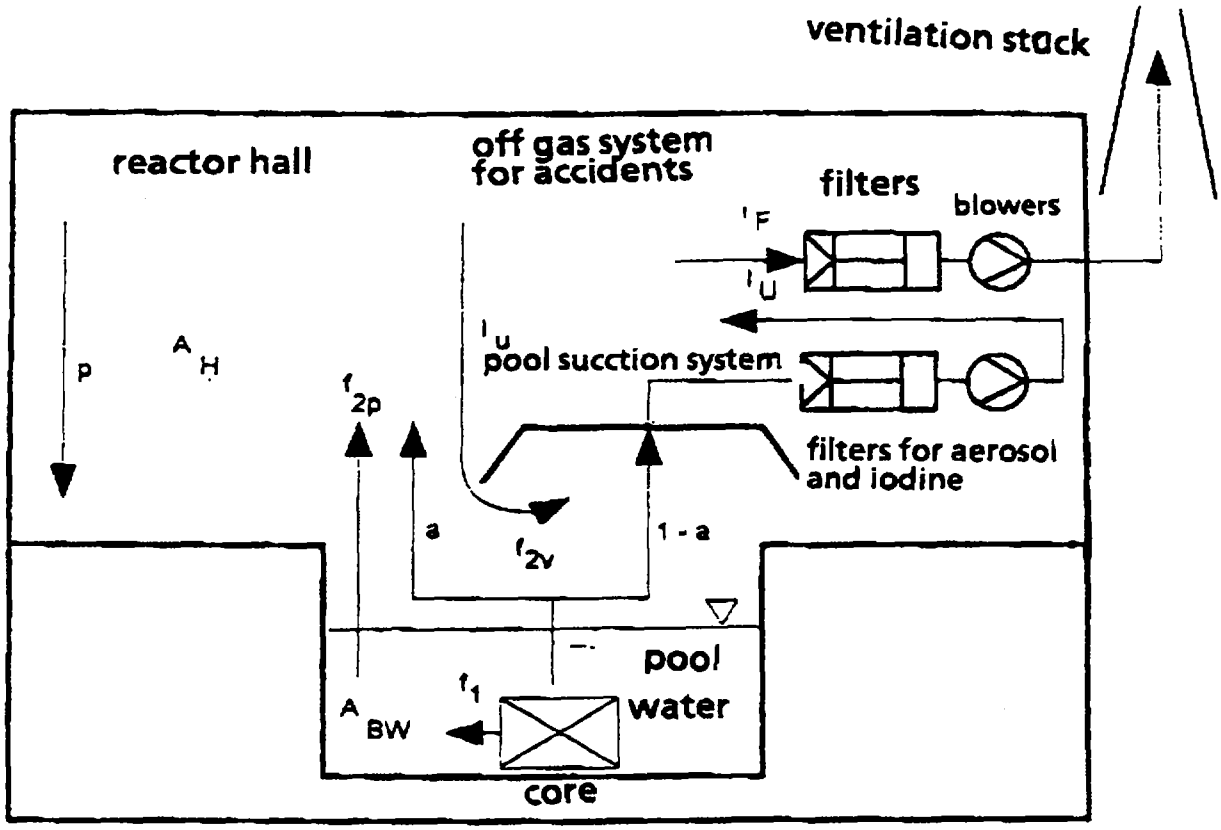

description of abbreviations

f_1 = prompt release into pool water

f_{2p} = prompt release into reactor hall

f_{2v} = delayed release via evaporation

a = part of evaporation not taken by the pool suction system

l_F = off gas rate

l_U = circulation rate

p = plate out rate

A_H/A_{BW} = activity concentration in reactor hall and pool water

DF_U/DF_F = retain factors of ventilation systems

principle flow sheme for fission product releases

Fig. 4

Release factor, molten core under water

fission groups	release factor melt / water (f1)	retaining factor water / air (f2)	release fraction f1 * f2
	1,0	1,0	1,0
Halogene	0,75	$5 \cdot 10^{-4}$	$3,8 \cdot 10^{-4}$
Cäsium	0,25	$1 \cdot 10^{-5}$	$2,5 \cdot 10^{-6}$
	$1 \cdot 10^{-3}$	$1 \cdot 10^{-5}$	$1,0 \cdot 10^{-8}$

Fig. 5

	maximum dose (mSv) in the surrounding				limiting values with regard to § 28, Abs. 3 StrlSchV
	up to 2000 m		more than 2000 m		
	children	adults	children	adults	(mSv)
Bladder	1,41	1,18	0,41	0,34	150
Breast	1,97	1,64	0,57	0,47	150
Upper intestine	1,39	1,16	0,40	0,34	150
Lower intestine	1,32	1,10	0,38	0,32	150
Small intestine	1,35	1,13	0,39	0,33	150
Brain	1,85	1,54	0,54	0,45	150
Skin	2,82	2,56	1,11	1,01	300
Testicles	1,63	1,36	0,47	0,39	50
Bone - Surface	2,23	1,86	0,65	0,54	300
Liver	1,48	1,24	0,43	0,36	150
Lungs	1,65	1,37	0,48	0,40	150
Stomach	1,51	1,26	0,44	0,36	150
Spleen	1,51	1,25	0,44	0,36	150
Suprarenal gland	1,41	1,17	0,41	0,34	150
Kidneys	1,51	1,26	0,44	0,36	150
Ovaries	1,28	1,07	0,37	0,31	50
Pancreas	1,34	1,12	0,39	0,32	150
Red bone marrow	1,47	1,23	0,43	0,36	50
Thyroid	1,93	1,61	0,63	0,48	150
Thymus	1,64	1,37	0,48	0,40	150
Uterus	1,26	1,05	0,36	0,30	50
Effective dose	1,68	1,40	0,49	0,41	50

effective doses for design basis accident **Fig. 6**

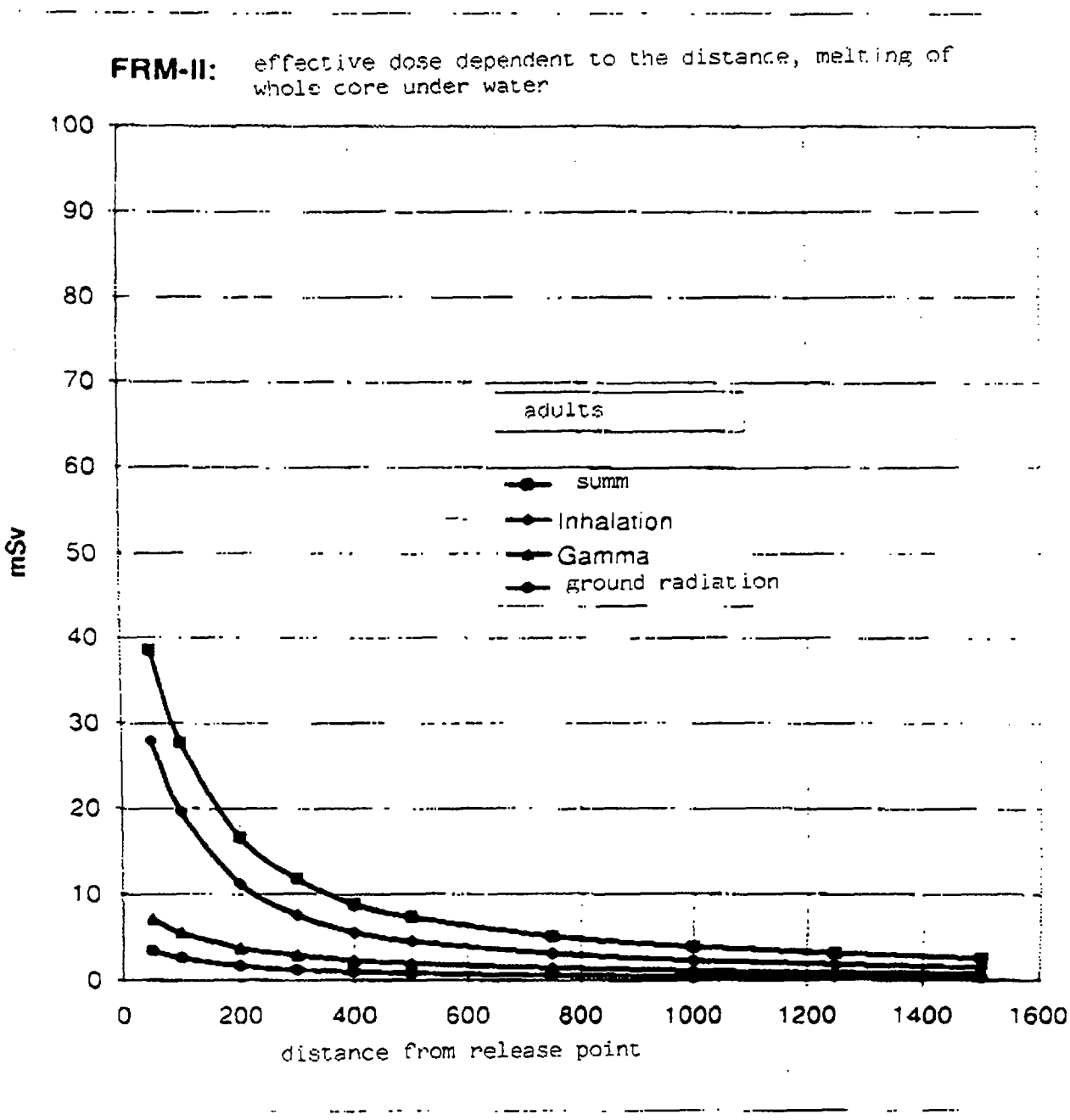
FRM-II: effective dose dependent to the distance, melting of whole core under water
100
90
80
70
60
50
40
30
20
10
0
mSv
adults
summ
Inhalation
Gamma
ground radiation
0
200
400
600
800
1000
1200
1400
1600
distance from release point

Fig. 7

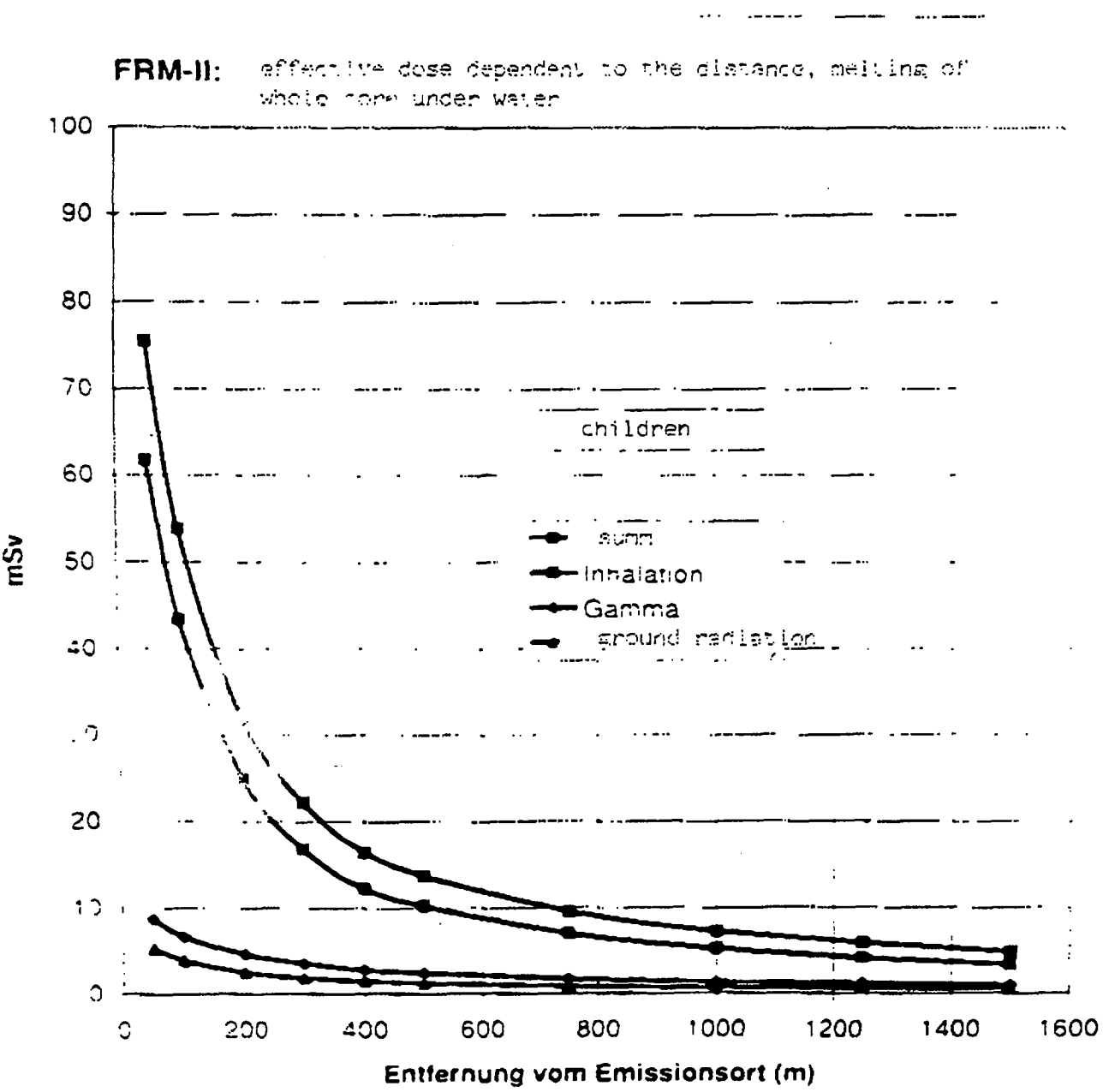
FRM-II:
children
sum
Inhalation
Gamma
ground radiation
mSv
100
90
80
70
60
50
40
20
0
0
200
400
600
800
1000
1200
1400
1600
Entfernung vom Emissionsort (m)

Fig. 8