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Emergency Planning

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DOCUMENTAZIONE PER LA LEZIONE SULLA SCALA DEGLI INCIDENTI NUCLEARI

1. **Slides (M. Mazzini)**
2. **Appendix E of 10 CFR 50: “Emergency Planning and Preparedness for Production and Utilization Facikities”**

   NRC, April 2012

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INTRODUCTION

Emergency planning shall be already considered at the early stage of NPP siting, with respect to its general feasibility:

- **Population density and distribution**
- **Characteristics of the environment** which influence the radioactivity transfer to man
- **Infrastructures** present in the region.

Common Aspects of Radiological and Chemical Emergencies (1/2)

A radiological emergency presents aspects very similar to those of a release of toxic substances, particularly if odourless, tasteless and invisible.

Also available protective measures are of very similar types, as the requirements for special instruments, laboratory facilities and trained personnel.

Common Aspects of Radiological and Chemical Emergencies (2/2)

Common elements in the assessment:

- Need of close cooperation between on-site and off-site authorities
- Need of essential information: **organized, easily understandable, clear and unambiguous, concise.**
- Difficulty to achieve accuracy in the assessment of the source term
- Evolutionary nature of the assessment process

Diversity Aspects of Radiological and Chemical Emergencies

The main differences between radiological and chemical emergencies are related to:

- Specific assessment technologies

and, in particular,

- Instrumentation available for on line evaluation of releases, concentrations of dangerous substances and related doses.

Fundamental Factors Affecting Accident Consequences (1/2)

1. Source term (release quantity and rate, duration, ..)
2. Time of the release (season, day, hour of the day)
3. Environmental dispersion (air or water)
4. Location (characteristics of the environs)
5. Population distribution and characteristics (age distribution, cultural level, preparedness, ...)
6. Effectiveness of the emergency response.

Fundamental Factors Affecting Accident Consequences (2/2)

Once the accident had occurred, factors 1-4 cannot be altered (**actually factor 1 can be modified by accident management**). Also factor 6 is already largely determined by prior emergency planning and exercises and factor 5 is largely predetermined by siting. However these two factors are the only ones on which to act **(sheltering and evacuation measures, control of food and water, ...)** at the time of the accident.

IN THE FOLLOWING ATTENTION IS FOCOUSED ON ATMOSPHERIC RELEASES.

Factors of Atmospheric Dispersion

The main factors which determine, in addition to the source term characteristics, the accident consequences are:

- **Meteorological conditions prevailing during and after the release**
- **Height of release and topography in plume direction**
- **Plume rise (also due to decay heat produced inside the plume).**

Factors Related to Population

- Age distribution
- Housing types (shielding effects and possibility of shelter, particularly underground)
- Social pattern (presence of large industrial or commercial installations, prisons, schools, hospitals, etc.)
- Socio-economic characteristics (cultural and socio-economical level of the various groups, possibility of autonomous movement, etc.)
- Preparedness and prompt information of emergency

Armamentarium of Emergency Responses

- Control of access and egress
- Temporary shielding and shelter
- Evacuation
- Individual protective means
- Diversion of food and water supply
- Decontamination of persons
- Medical prophylaxis **(only for blocking iodine absorption in the thyroid).**
- Decontamination of areas

Emergency Phases

1. **Early phase (hours to days); risk determined by inhalation and irradiation from the plume.**
2. **Intermediate phase (days to weeks); risk determined by irradiation from the ground and ingestion of fresh foods.**
3. **Late phase (weeks to years); risk determined by consumption of contaminated food and irradiation from contaminated environment.**

APPLICABILITY OF PROTECTIVE MEASURES

Protective measure	Phase		
	Early	Intermediate	Late
Sheltering	**	*	–
Radioprotective prophylaxis	**	*	–
Control of access and egress	**	**	*
Evacuation	**	**	–
Personal protective methods	*	*	–
Decontamination of persons	*	*	*
Medical care	*	**	*
Diversion of food and water supplies	**	**	**
Use of stored animal feed	**	**	**
Decontamination of areas	–	*	**

** applicable and possibly essential

* applicable

– not applicable or of limited application

TABLE IV - RELEVANCE OF PROTECTION MEASURES TO PARTICULAR HAZARDS

Potential Hazard Routes	Time-Scale	Applicable Protective Measures for General Public
Direct radiation from facility	Early phase	Evacuation Control of access
1-Direct radiation from plume (and possibly ground deposition)	Early phase	Sheltering Control of access Evacuation
2-Inhalation of volatiles (e.g.Iodine)	Early phase	Sheltering Radioprotective prophylaxis Control of access Evacuation Personal protective methods
3-Inhalation of aerosols	Early phase	Sheltering Control of access Evacuation Personal protective methods
4-Contamination of skin and clothes	Intermediate phase	Sheltering Control of access Evacuation Decontamination of persons
5-Inhalation of resuspended particules	Intermediate phase	Evacuation Control of access Personal protective methods Decontamination of areas
6-Radiation from ground deposition	Late phase	Evacuation Control of access Sheltering Decontamination of areas
7-Ingestion of contaminated food and water	Late phase	Diversion of food and water

Notes
1. Medical care may be required in any of the time-scale phases, and should be implemented by competent authorities when and if necessary
2. The use of stored animal feeds to limit the uptake of radionuclides by domestic animals in the food-chain can be applicable in any of the time-scale phases.

Classifying the Emergency

A four level classification is convenient and commonly used for notifying Regulatory Body and giving early warning to the emergency response organizations:

1. Emergency stand-by (Alarm)
2. Plant emergency
3. Site emergency
4. Off-site emergency.

Emergency Planning

In USA the specific requirements for Emergency Planning and Preparedness for NPP are contained in Appendix E to 10CFR50.

It has been recently updated and covers also acts of sabotage and terrorisms.

Emergency Planning

Emergency planning shall be considered already at level of PSAR and in the FSAR.

The main requirements of the Appendix E to 10CFR50 are specified in the points:

- **Content of Emergency Plans**
- **Implementing Procedures**
- **Emergency Response Data System**

Emergency Facilities and Equipment (1)

They include:

1. **Equipment at the site for personnel monitoring**
2. **Equipment for continuously assessing the release of radioactive materials to the environment**
3. **Facilities and supplies at the site for decontamination of onsite individuals**
4. **Facilities and medical supplies at the site for appropriate emergency first aid treatment**
5. **Arrangements for medical service providers qualified to handle radiological emergencies onsite**

Emergency Facilities and Equipment (2)

They include:

6. **Arrangements for transportation of contaminated injured individuals from the site to treatment facilities outside the site boundary**
7. **Arrangements for treatment of individuals injured**
8. **An onsite technical support center and an emergency operations facility from which effective direction can be given and effective control can be exercised during an emergency;**

Emergency Facilities and Equipment (3)

- **The emergency operations facility can be either a facility located between 10 miles and 25 miles of the nuclear power reactor site(s), or a primary facility located less than 10 miles from the nuclear power reactor site(s) and a backup facility located between 10 miles and 25 miles of the nuclear power reactor site(s).**
- **An emergency operations facility may serve more than one nuclear power reactor site.**

Emergency Facilities and Equipment (4)

The emergency operations facility shall have:

(1) The capability for obtaining and displaying plant data and radiological information;

(2) The capability to analyze plant technical information and provide technical briefings on event conditions and prognosis to licensee and offsite response organizations

(3) The capability to support response to events occurring simultaneously at more than one nuclear power reactor site

For nuclear power reactor licensees, an alternative facility (or facilities) that would be accessible even if the site is under threat of or experiencing hostile action, to function as a staging area for augmentation of emergency response staff and collectively having the following characteristics: the capability for communication with the emergency operations facility, control room, and plant security; the capability to perform offsite notifications; and the capability for engineering assessment activities, including damage control team planning and preparation, for use when onsite emergency facilities cannot be safely accessed during hostile action. The requirements in this paragraph 8.d must be implemented no later than December 23, 2014, with the exception of the capability for staging emergency response organization personnel at the alternative facility (or facilities) and the capability for communications with the emergency operations facility, control room, and plant security, which must be implemented no later than June 20, 2012.

Emergency Facilities and Equipment (3b)

-A licensee shall not be subject to the requirements of paragraph 8.b of this section for an existing emergency operations facility approved as of December 23, 2011;

- At least one onsite and one offsite communications system; each system shall have a backup power source. All communication plans shall have arrangements for emergencies, including titles and alternates for those in charge at both ends of the communication links and the primary and backup means of communication. Where consistent with the function of the governmental agency, these arrangements will include:

-Provision for communications with contiguous State/local governments within the plume exposure pathway EPZ. Such communications shall be tested monthly.

- Provision for communications with Federal emergency response organizations. Such communications systems shall be tested annually.

- Provision for communications among the nuclear power reactor control room, the onsite technical support center, and the emergency operations facility; and among the nuclear facility, the principal State and local emergency operations centers, and the field assessment teams. Such communications systems shall be tested annually.

- Provisions for communications by the licensee with NRC Headquarters and the appropriate NRC Regional Office Operations Center from the nuclear power reactor control room, the onsite technical support center, and the emergency operations facility. Such communications shall be tested monthly.

Emergency Facilities and Equipment (5)

For NPP, it is foreseen also an alternative facility (or facilities) that would be accessible even if the site is under threat of or experiencing hostile action, having the following characteristics:

- **the capability for communication with the emergency operations facility, control room, and plant security;**
- **the capability to perform offsite notifications;**
- **the capability for engineering assessment activities, including damage control team planning and preparation.**

Emergency Facilities and Equipment (6)

The emergency facilities and equipment include:

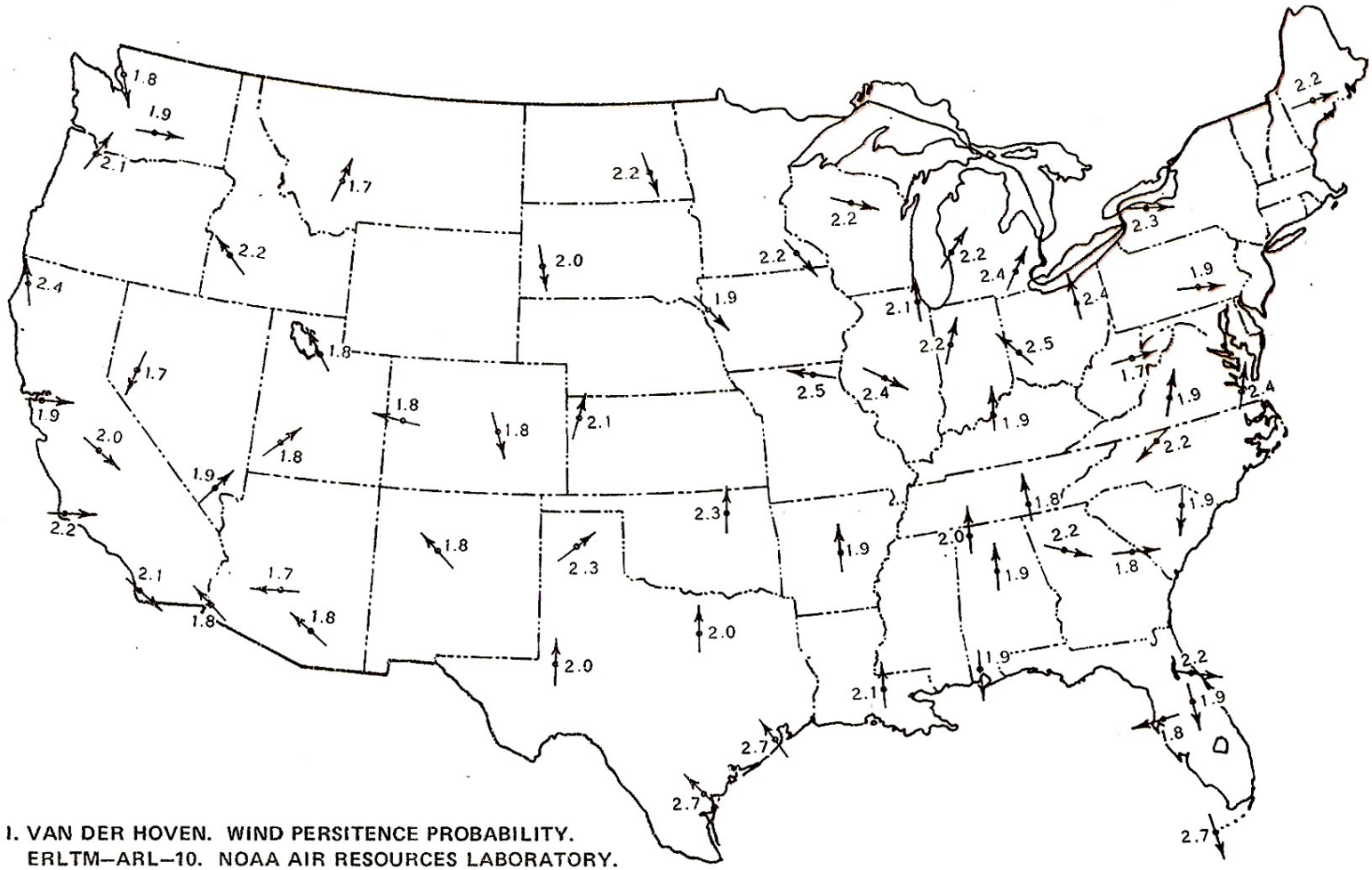
9. At least one onsite and one offsite communications system; each system shall have a backup power source. All communication plans shall have arrangements for emergencies, including provisions for communications with contiguous State/local governments within the plume exposure pathway EPZ and with Federal emergency response organizations.

Emergency Facilities and Equipment (7)

Other provisions shall assure

- **communications among the nuclear power reactor control room, the onsite technical support center, and the emergency operations facility;**
- **among the nuclear facility, the principal State and local emergency operations centers, and the field assessment teams;**
- **communications by the licensee with NRC Headquarters and the Regional Center from the NPP control room, the onsite technical support center, and the emergency operations facility.**

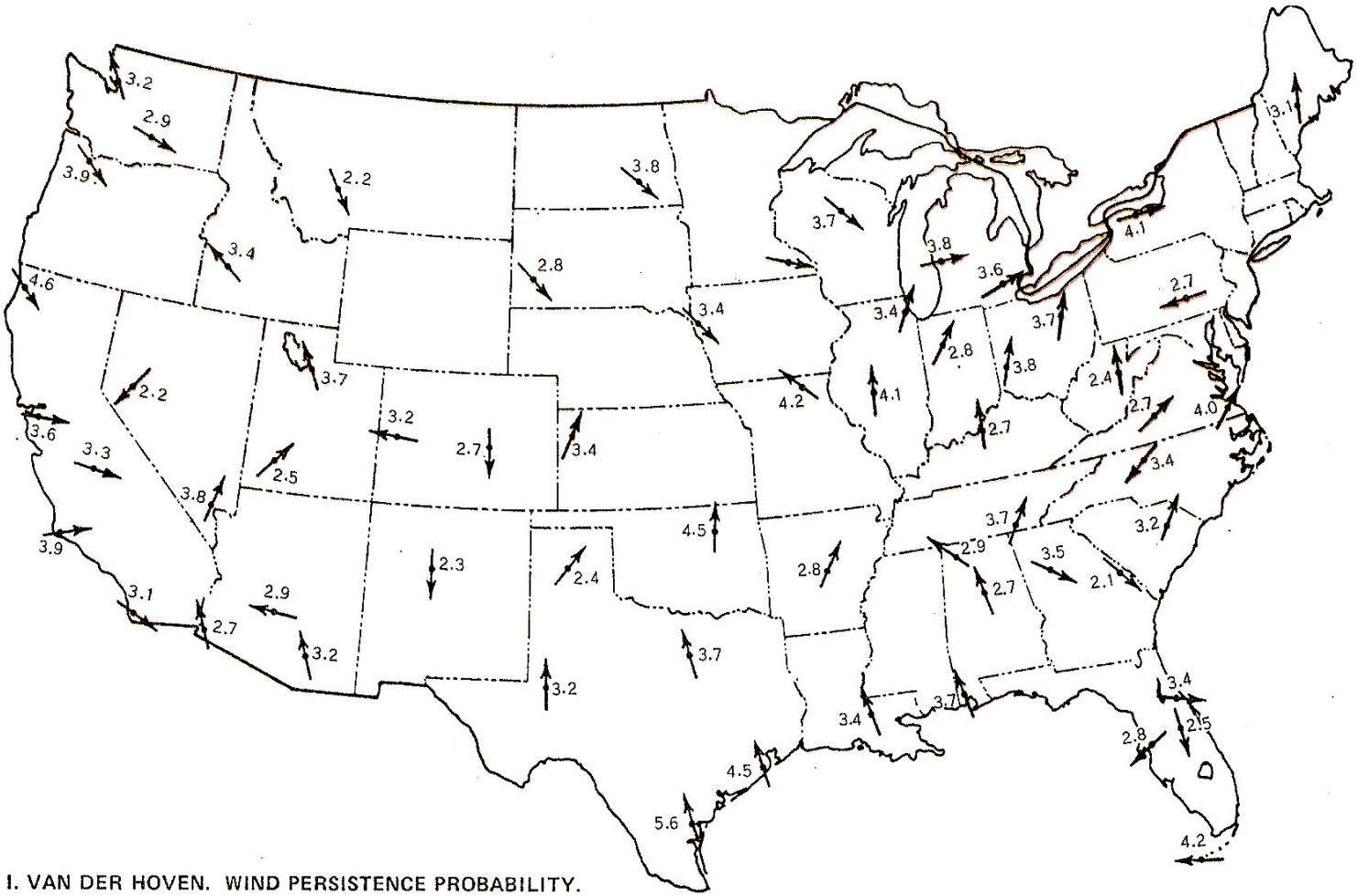
Wind Persistence



REF. I. VAN DER HOVEN. WIND PERSITENCE PROBABILITY.
ERLTM–ARL–10. NOAA AIR RESOURCES LABORATORY.
SILVER SPRING, MD. 20910

Highest 50-percent probability of hours of wind persistence in a 22½° sector centered on the indicated directions.

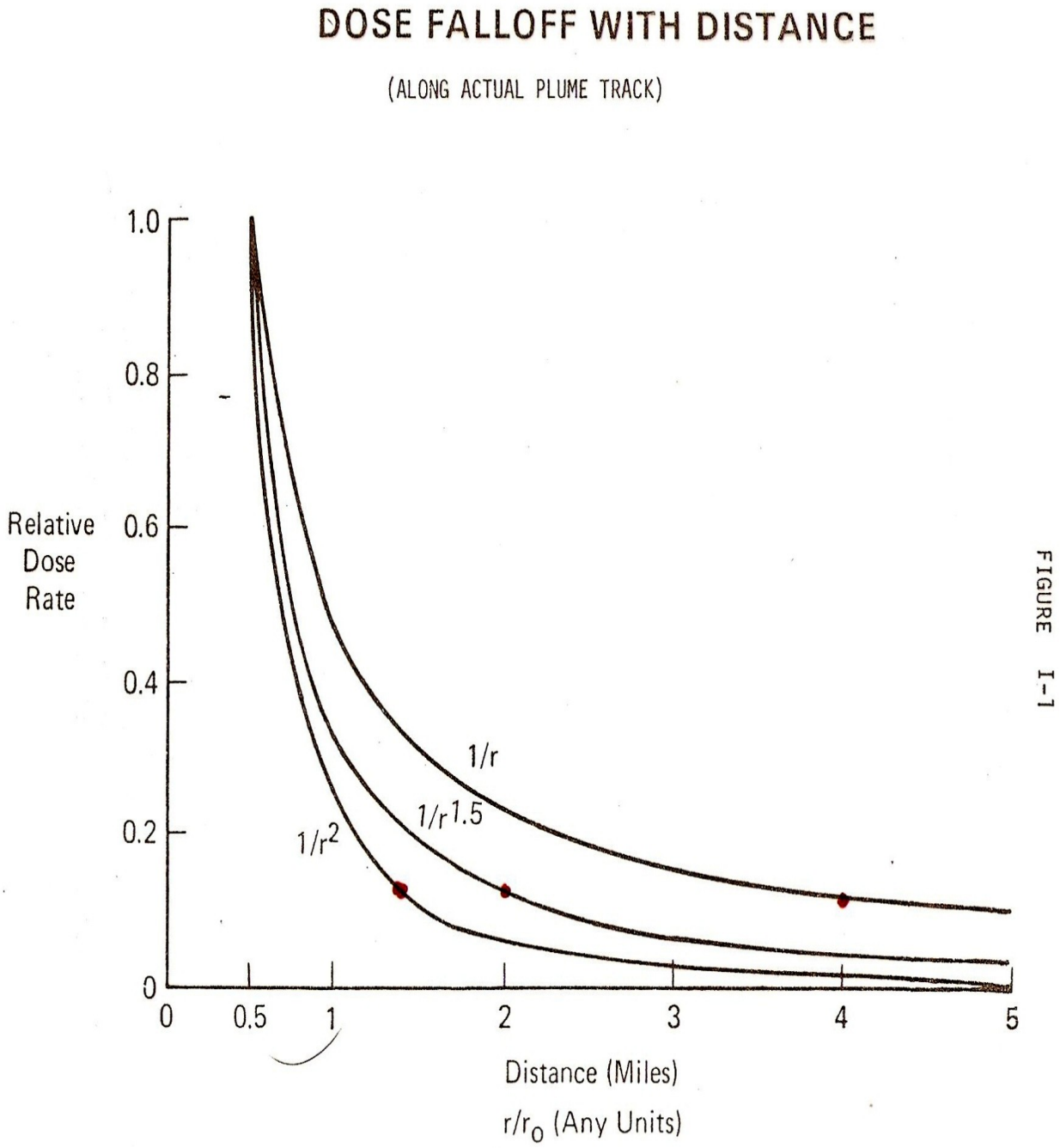
Wind Persistence



REF. I. VAN DER HOVEN. WIND PERSISTENCE PROBABILITY. ERLTM–ARL–10. NOAA AIR RESOURCES LABORATORY. SILVER SPRING, MD. 20910

Highest 50-percent probability of hours of wind persistence in a $67\frac{1}{2}^{o}$ sector centered on the indicated directions.

Emergency Planning



Emergency Planning

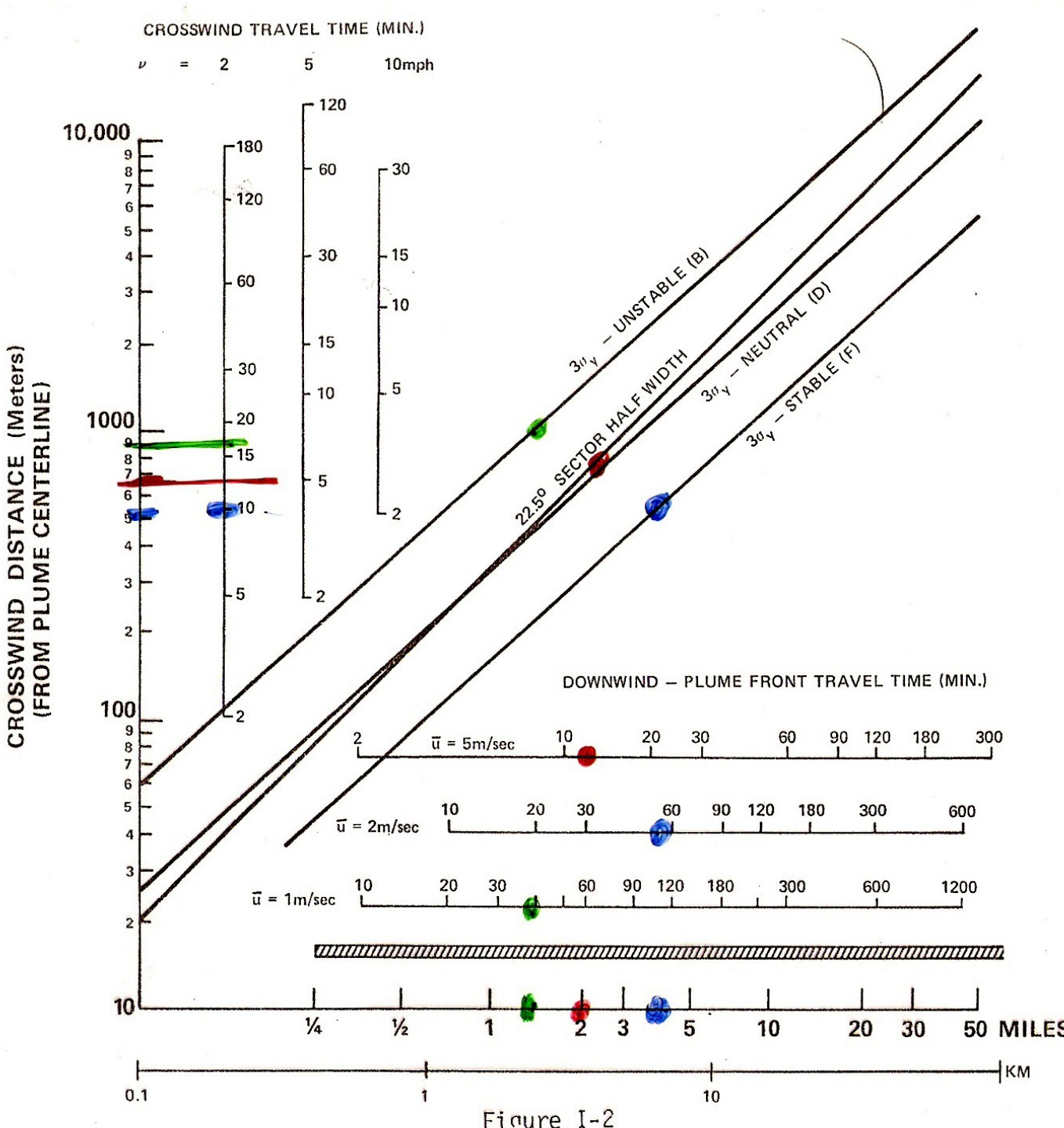
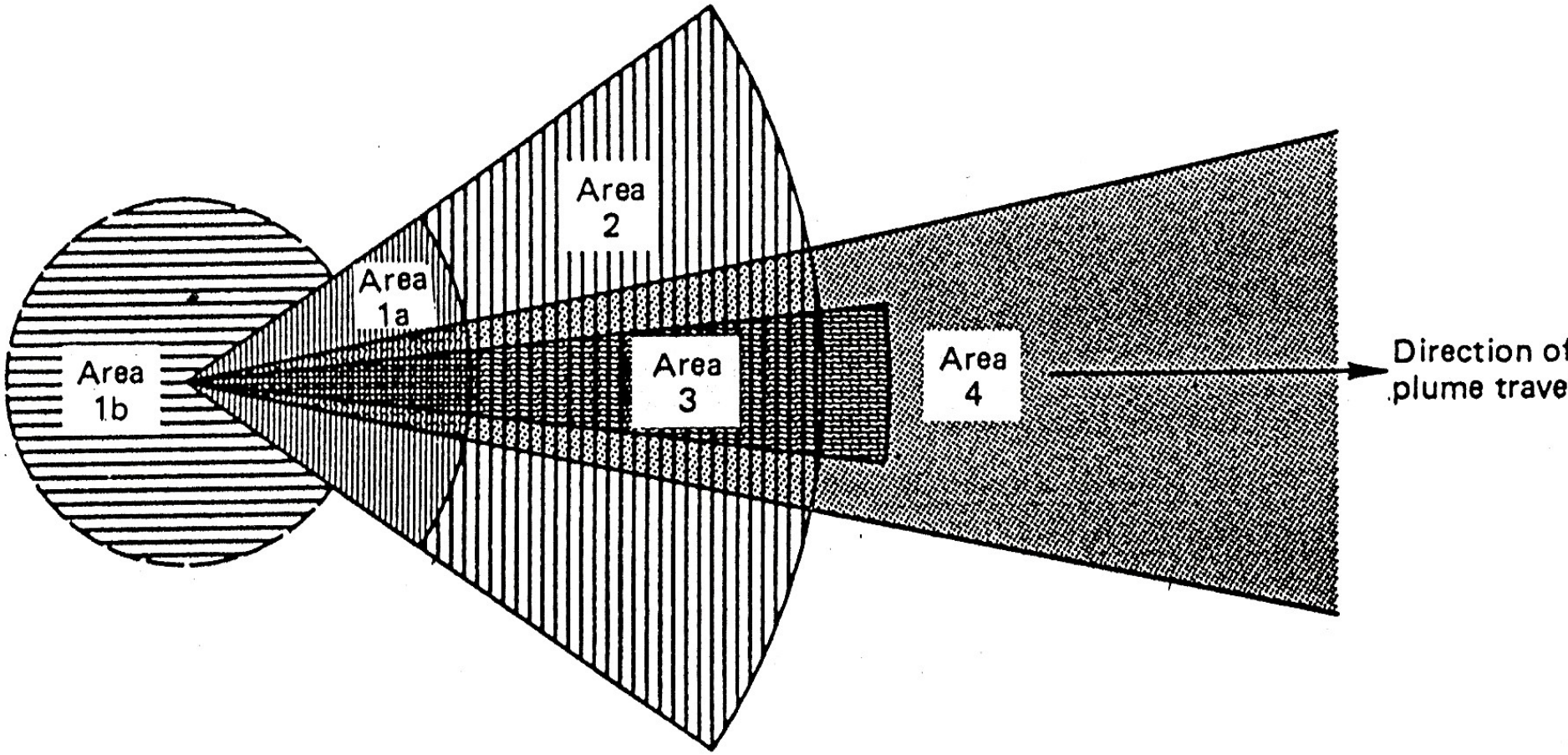


Figure I-2

Emergency Planning Zones (EPZ)



Emergency Planning Zones (EPZ)

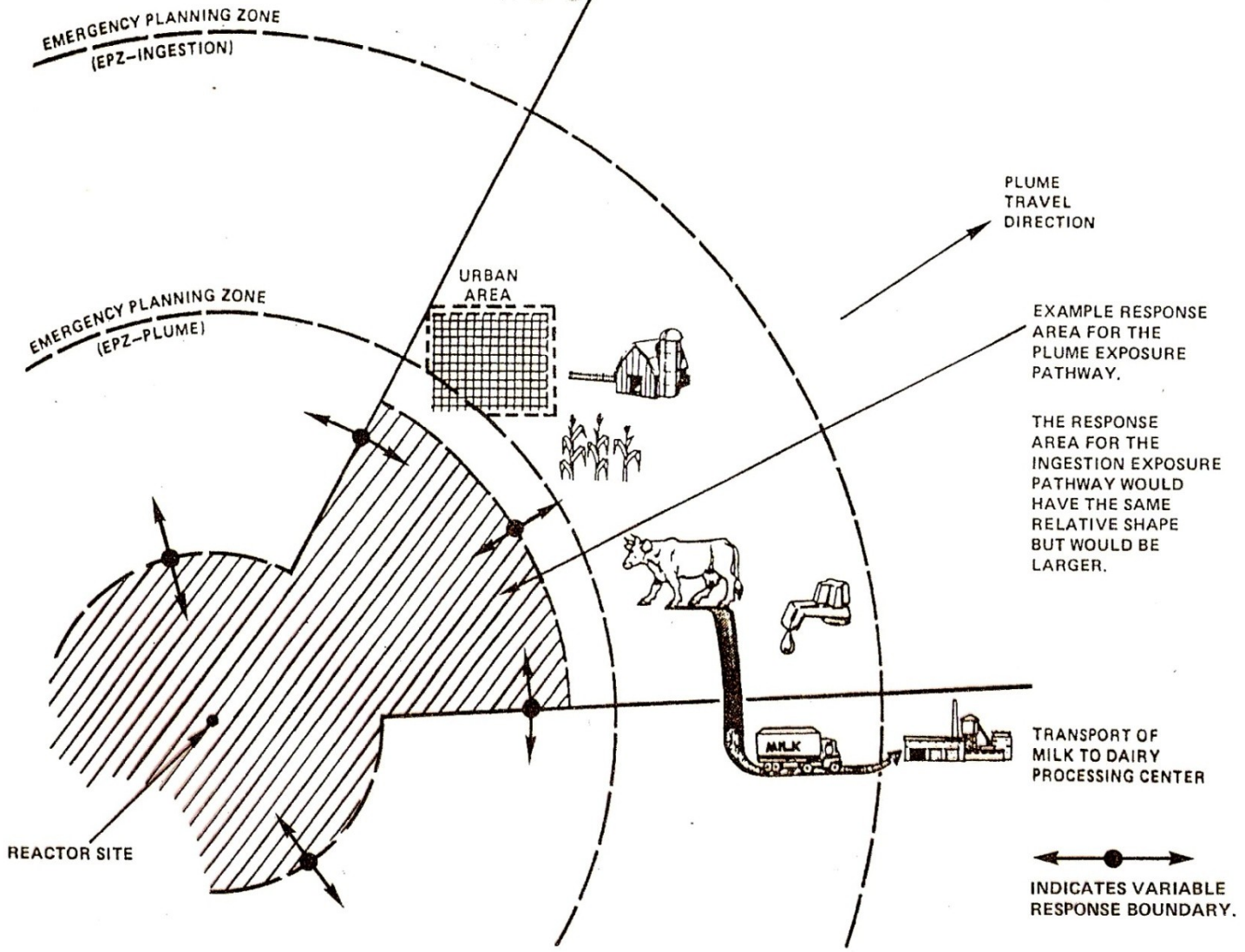


Figure 2. Concept of Emergency Planning Zones

Most Important Radionuclides

Table II.

RADIONUCLIDES WITH SIGNIFICANT CONTRIBUTION TO DOMINANT EXPOSURE MODES

Radionuclides with Significant Contribution to Thyroid Exposure

Radionuclide	Half Life (days)
I-131	8.05
I-132	0.0858
I-133	0.875
I-134	0.0366
I-135	.028
Te-132	3.25
Kr-88	0.117

Radionuclides with Significant Contribution to Whole Body Exposure

Radionuclide	Half Life (days)
I-131	8.05
Te-132	3.25
Xe-133	5.28
I-133	0.875
Xe-135	0.384
I-135	.028
Cs-134	750
Kr-88	0.117
Cs-137	11,000

Radionuclides with Significant Contribution to Lung Exposure* (Lung only controlling when thyroid dose is reduced by iodine blocking or there is a long delay prior to releases)

Radionuclide	Half Life (days)
I-131	8.05
I-132	0.0858
I-133	0.875
I-134	0.0366
I-135	.028
Cs-134	750
Kr-88	0.117
Cs-137	11,000
Ru-106	365
Te-132	3.25
Ce-144	284

*Derived from the more probable U.S. Reactor Safety Study fuel melt categories and from postulated design basis accident releases.

Dose Conversion Factors

TABLE V. DOSE CONVERSION FACTORS (DERIVED FROM MODELS) FOR CALCULATING DOSES TO INDIVIDUA FROM $\chi u/Q$ FROM ONE HOUR'S EXPOSURE BY VARIOUS PATHWAYS

Nuclide	Immersion	Deposition	Inhalation	Forage–cow–milk	Pasture–meat	Leafy vegetable
	$(Sv \cdot m^3 \cdot Bq^{-1})$ $(mrem \cdot m^3 \cdot Ci^{-1})$	$(Sv \cdot m^2 \cdot Bq^{-1})$ $(mrem \cdot m^2 \cdot Ci^{-1})$	$(Sv \cdot m^3 \cdot Bq^{-1})$ $(mrem \cdot m^3 \cdot Ci^{-1})$	$(Sv \cdot m^2 \cdot Bq^{-1})$ $(mrem \cdot m^2 \cdot Ci^{-1})$	$(Sv \cdot m^2 \cdot Bq^{-1})$ $(mrem\ m^2 \cdot Ci^{-1})$	$(Sv \cdot m^2 \cdot Bq^{-1})$ $(mrem \cdot m^2 \cdot Ci^{-}$
Sr-90	0 (0)	0 (0)	7.3×10^{-7} (2.7×10^{9}) (adult bone)	6.2×10^{-4} (2.3×10^{12}) (infant bone)	6.5×10^{-4} (2.4×10^{12}) (adult bone)	5.4×10^{-4} (2.0×10^{12}) (adult bone)
I-131	1.4×10^{-11} (3.1×10^{5}) (adult whole body)	1.5×10^{-12} (5.4×10^{3}) (adult whole body)	3.0×10^{-7} (1.1×10^{9}) (adult thyroid)	6.2×10^{-3} (2.3×10^{13}) (infant thyroid)	7.3×10^{-5} (2.7×10^{11}) (adult thyroid)	3×10^{-4} (1.1×10^{12}) (adult thyroid)
Cs-137	1.2×10^{-10} (4.3×10^{5}) (adult whole body)	2.1×10^{-12} (7.9×10^{3}) (adult whole body)	1.1×10^{-8} (4.0×10^{7}) (adult whole body)	2.4×10^{-4} (9.0×10^{11}) (infant whole body)	2.1×10^{-5} (7.9×10^{10}) (adult whole body)	2.7×10^{-5} (1.0×10^{11}) (adult whole body)

Doses for Early Phase Protective Measures

Protective Measure	Whole Body Dose (mSv)	Dose to a single organ preferentially irradiated (mSv)
Sheltering	5 - 50	50 - 500
Evacuation	50 - 500	500 - 5000

For thyroid case, the administration of stable iodine is recommended if the foreseen dose is in the range 50–500

Effectivness of Emergency Protective Means

TABLE V.

RESPIRATORY PROTECTION PROVIDED BY COMMON HOUSEHOLD AND PERSONAL ITEMS AGAINST AEROSOLS OF 1 TO 5μ PARTICLE SIZE

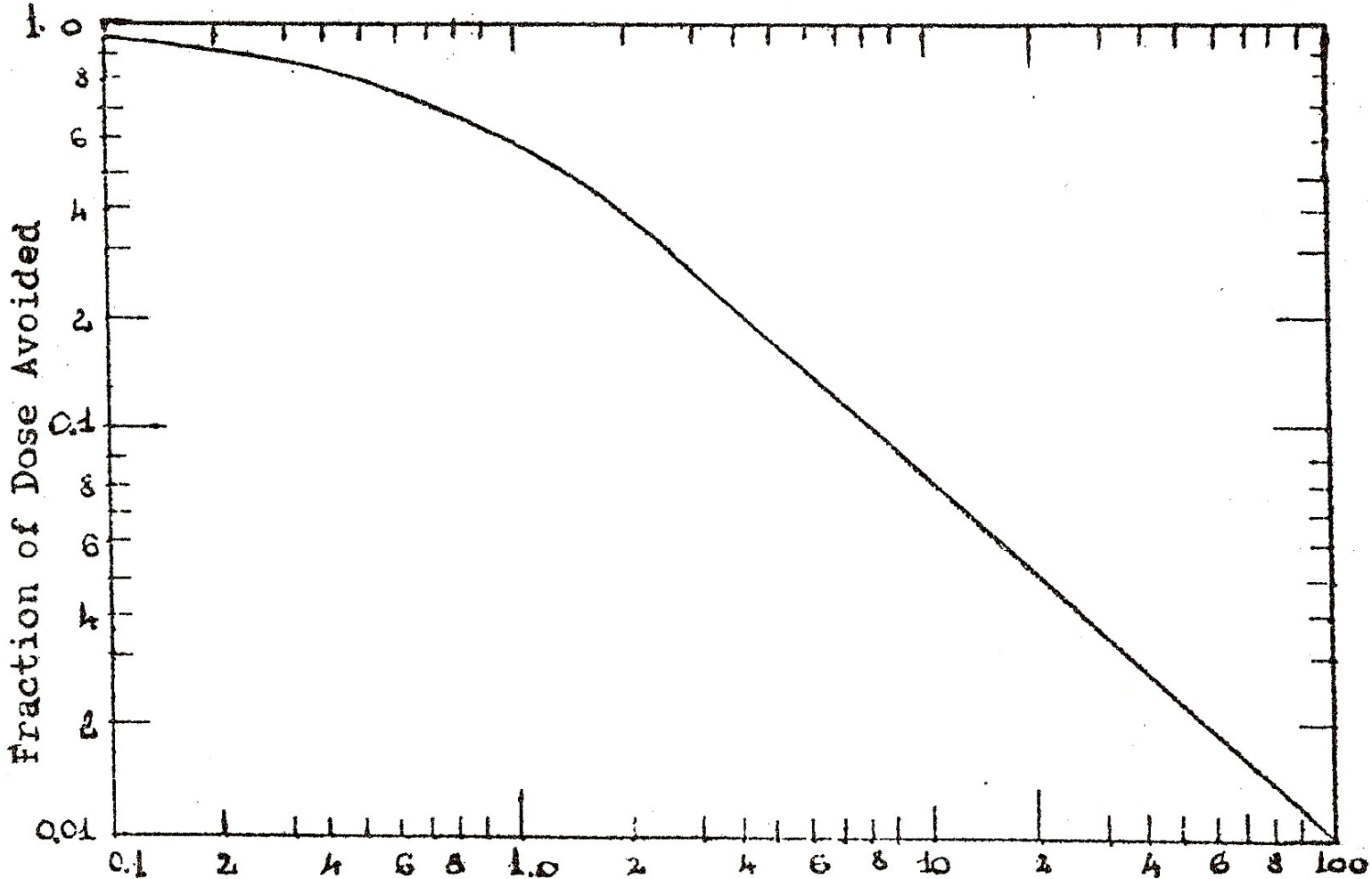
Item	Number of Thick-nesses	Resistance mm of H_2O	Geometric Mean Efficiency, %
Handkerchief, man's cotton	16	36	94.2
Toilet paper	3	13	91.4
Handkerchief, man's cotton	8	18	88.9
Handkerchief, man's cotton	Crumpled	-	88.1
Bath towel, turkish	2	11	85.1
Bath towel, turkish	1	5	73.9
Bed sheet, muslin	1	22	72.0
Bath towel, turkish	1 (wet)	3	70.2
Shirt, cotton	1 (wet)	150[a]	65.9
Shirt, cotton	2	7	65.5
Handkerchief, woman's cotton	4 (wet)	84[a]	63.0
Handkerchief, man's cotton	1 (wet)	98[a]	62.6
Dress material, cotton	1 (wet)	180[a]	56.3
Handkerchief, woman's cotton	4	2	55.5
Slip, rayon	1	6	50.0
Dress material, cotton	1	5	47.6
Shirt, cotton	1	3	34.6
Handkerchief man's cotton	1	2	27.5

a. Resistance obtained when checked immediately after hand wringing. This resistance began to decrease after about one minute when the material started to dry.

Reference: American Industrial Hygiene Assn-1963
RESPIRATORY PROTECTIVE DEVICES MANUAL

Effectiveness of Emergency

Figure I. Effect of ventilation rate and immersion time on fraction of dose



Effectivness of Emergency Shielding

Representative reduction factors for cloud source

Structure location	Reduction factor
Outside	1.0
Vehicles	1.0
Wood frame house, no basement	0.9
Masonry house, no basement	0.6
Basement of wood frame house	0.6
Basement of masonry house	0.4
Large office or industrial-type building away from doors and windows	0.2 or less

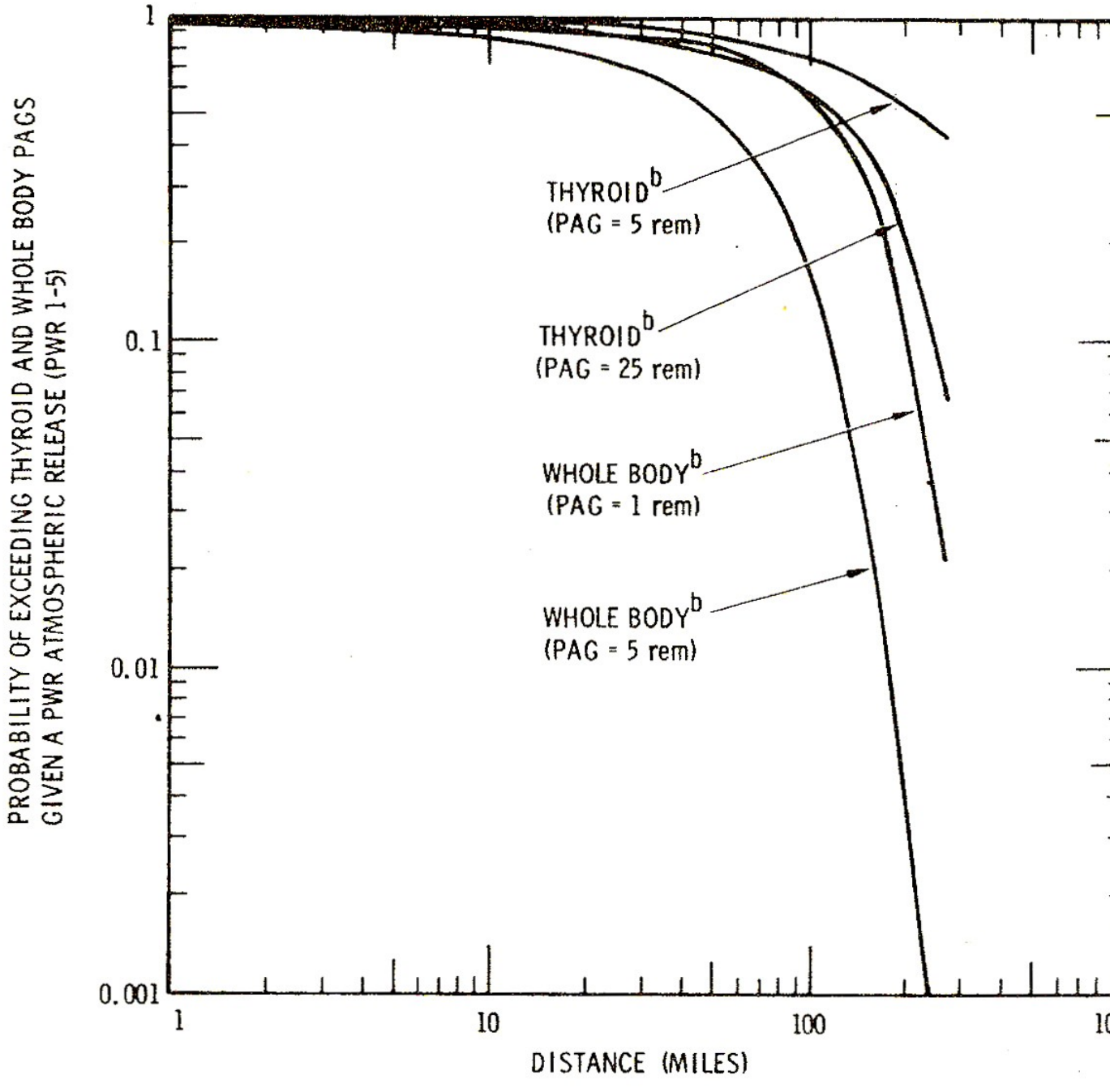
/:Health Physics Pergamon Press 1977. Vol.33/September/pp.287-298.:/

Representative reduction factors for deposited radioactivity

Structure and/or location	Reduction factor
1 m above a hypothetical infinite smooth plane	1.00
1 m above ordinary ground	0.70
1 m above center of 50-ft roadway half way contaminated	0.55
cars, pickups, buses and trucks on 50-ft road	
road fully contaminated	0.5
road 50% contaminated	0.5
road fully decontaminated	0.25
Trains	0.4
1 & 2-story wood frame homes (no basement)	0.4
1 & 2-story block or brick homes (no basement)	0.2*
Home basement - 1 or 2 walls fully exposed	0.1*
- 1-story less than 2 ft of basement walls exposed	0.05*
- 2-story, less than 2 ft of basement walls exposed	0.03*
3 or 4-story structures, 5000-10 000 ft per floor	
first and second floors	0.05*
basement	0.01*
multi-story structures> 10 000 ft^2 per floor	
upper floors	0.01*
basement	0.005*

* Away from doors and windows

Emergency Extension

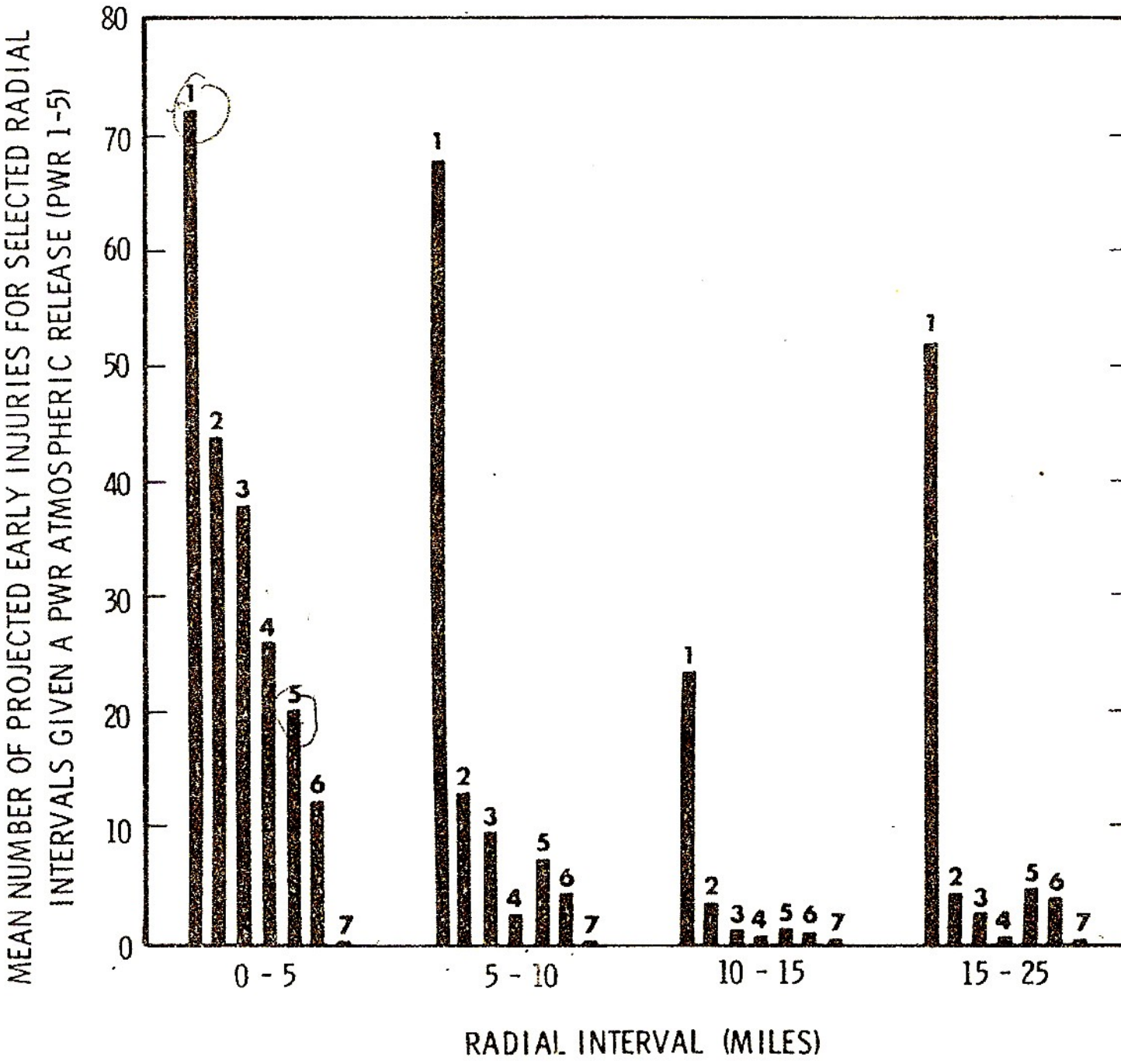


Emergency Effectivness

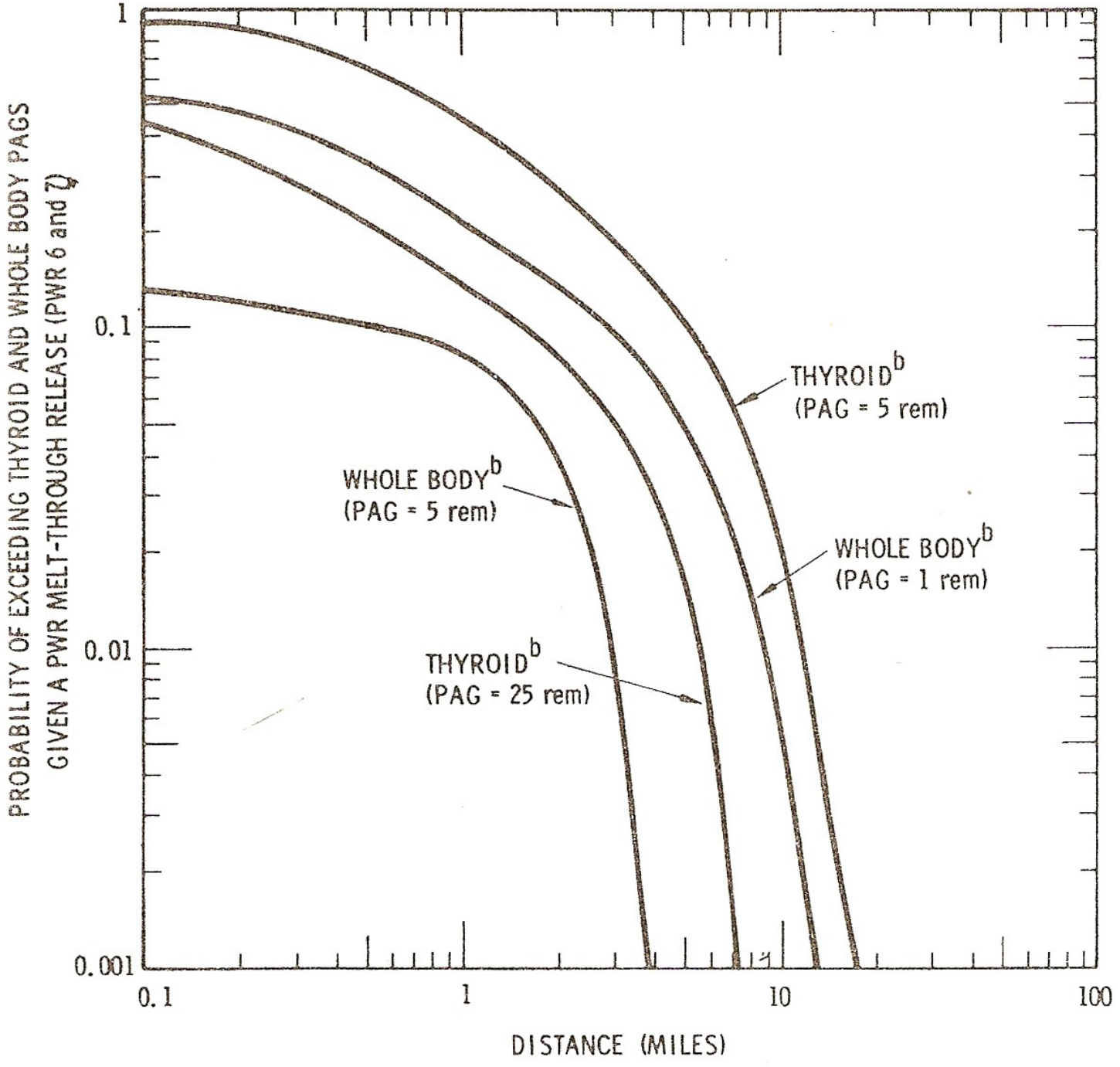
Legenda

1. No immediate protective action. SF (0.75;0.33). Exposure 1 day
2. Sheltering. SF (0.75;0.33). Exposure 6 hours
3. Sheltering. SF (0.50;0.08). Exposure 1 day
4. Sheltering. SF (0.50;0.08). Exposure 6 hours
5. Evacuation 10 MPH, 5 hours of delay
6. Evacuation 10 MPH, 3 hours of delay
7. Evacuation 10 MPH, 1 hours of delay

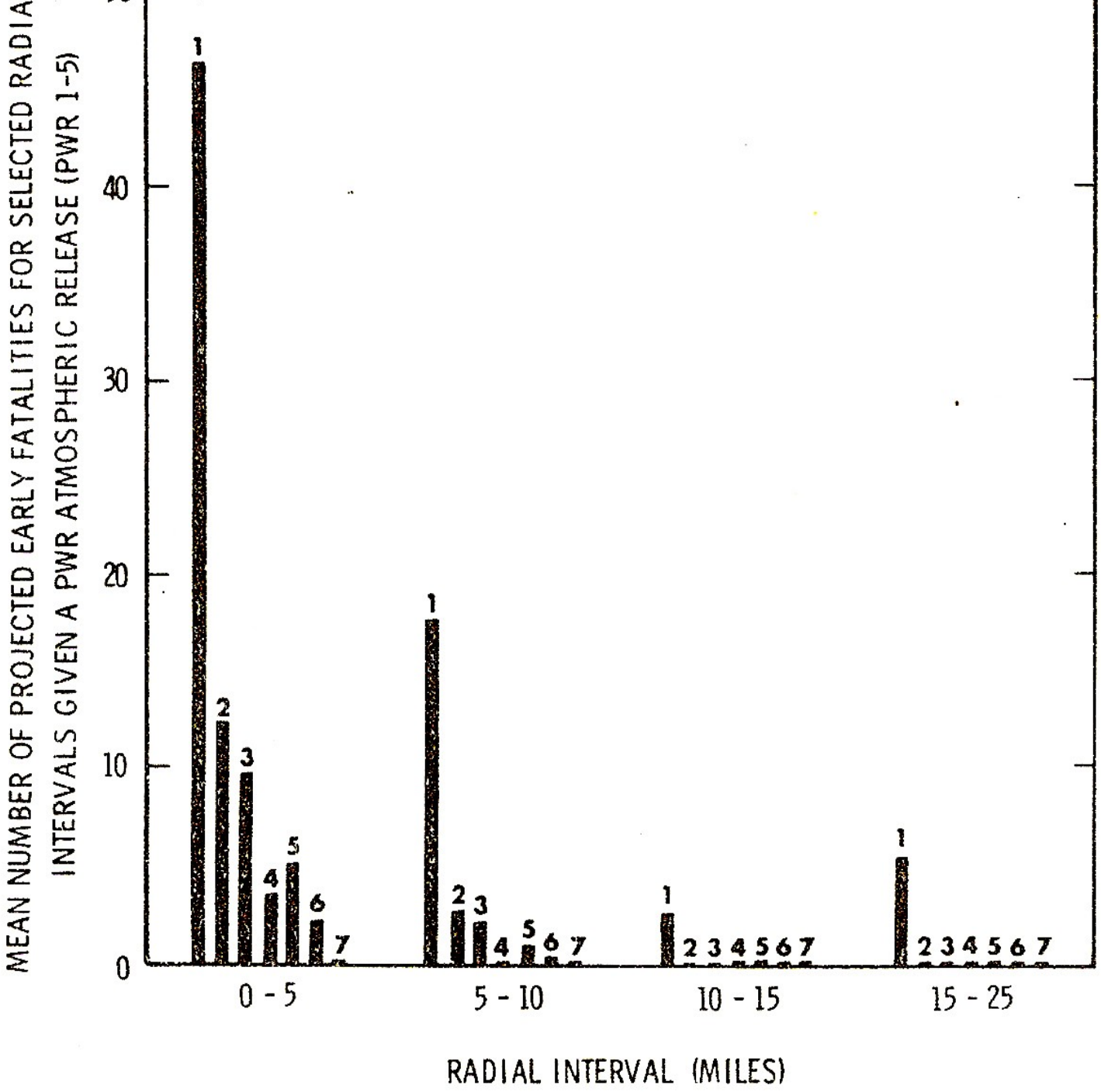
Emergency Effectivness



Emergency Extension



Emergency Effectivness



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