RADIOACTIVE WASTE MANAGEMENT FOR NUCLEAR POWER PLANTS

CHARLES A. WILLIS
Nuclear Reactor Safety Expert
International Atomic Energy Agency

8 August 1979

Seminar for Mechanical Engineering Teachers
De La Salle University
Manila

I. Functions

A. Control Wastes

B. Measure Releases

C. Control Releases to "As Low as Reasonably Achievable"

II. Liquid Waste System

A. Boron Recycle System (Augments LWS)

B. Train A (Tritiated aerated water)

1. Sources: Drain Header & Sample room sinks
2. Waste Holdup tank
3. Waste Evaporator
4. Waste Evaporator Demineralizer
5. Filter
6. Waste Condensate Tank
7. Pump
8. To: R Makeup, Boron Recycle or waste Holdup tank

C. Train B (Non-reactor grate water)

1. Sources: Floor drain header & Bldg., pumps
2. Floor drain tanks
3. Pump
4. Skimmer
5. Filter
6. Waste Evaporator
7. Waste Evaporator Demineralizer
8. Filter
9. Waste Monitor tank demineralizer

10. Filter
11. Waste Monitor Tank 2
12. Pump
13. Radiation
14. Discharge

D. Chemical Wastes

1. Source: Spent samples
2. Chemical Drain tank
3. Pump
4. To: Spent Sampling Package

E. Detergent Wastes

1. Source: Laundry, handwash & hot shower drains
2. Laundry & Hot Shower Drain tank
3. Pump
4. Skimmer
5. Filter
6. Waste monitor tank 1
7. Pump
8. Radiation monitor
9. Discharge

F. Spent Resin Waste

1. Source demineralizers: Waste monitor tank, CVS mixed bed, B Recycle evaporator feed, CVSS cation bed, B Recycle condensate, Spent Fuel pit, Waste evaporator
2. Spent resin storage tank
3. Pump
4. Filter
5. To: Resin packaging

III. Gaseous Waste System

A. Gaseous Waste Processing System

1. Sources: Volume control tank, recycle evaporator vent, condenser, waste evaporator vent, condenser, recycle holdup tank, RC drain tank
2. Compressors
3. Catalytic recombiners
4. Gas decay tank
5. Return to CVCS

B. HVAC (Section 9.4)

IV. Solid Radioactive Wastes System

A. Principal solid wastes

1. Spent demineralizer resins
2. Evaporator bottoms
3. Chemical drain tank contents
4. Spent filter cartridges
5. Miscellaneous, compressible & incompressible

B. Solidification process

1. 300 gal. holdup tanks
2. Pumps
3. Cement mixer & feeder
4. Chemical addition system
5. Drum loading sleeve
6. Container cart
7. Overhead crane (7.5 tons)
8. Drum capping machine
9. Container "swipe" tool
10. 55 gallon drums

C. Filters: Filter transfer shield assembly

D. Miscellaneous compressible: hydraulic valve

V. Review Concerns

A. Source Terms

1. Are parameters used consistent with NUREG-0016?
2. All potential release points detailed
   a. Concentrations in primary coolant; fission products and others
   b. Leak points and rate
   c. Gaseous wastes: noble gases, radioiodine, carbon-14
   d. Gaseous waste sources: SG blowdown, main condenser, leakage to containment, fuel handling system, turbine bldg., gases stripped from coolant and cover and vent gases
   e. Liquid wastes: primary coolant (shim bleed), drains SG blowdown, condensate demineralizer regenerant solutions, resin sluees, filter backwashes, decon solutions, samples, and detergent wastes.
3. Volumes and radiation levels consistent with NUREG-0016

4. Decontamination factors (Iodine removal, HEPA filters, etc.) consistent with NUREG-0016

B. Liquid Waste Management Systems

1. Meet 10CFR 20 and 10CFR 50 appendix d
   a. Off site annual doses less than 3 mrem WB and 10 mrem to any organ
   b. Include all cost-effective controls ($1000 per manrem or thyroid rem)
   c. 10CFR 20 limits met
2. Capacity meets requirements
   a. Single Failure
   b. Operations generation excessive waste
   c. Design basis leakage levels (1%)
3. Meet seismic quality requirements of RG 1.143
4. Operability and maintainability, RG 1.143
5. Design, construct and test to code (ASME II, VIII and X; ANSI 31.1)
6. Tanks must have:
   a. Liquid level monitors and alarms
   b. Overflows, sample and drain lines to LRTS
   c. Curbs, dikes or retention ponds

C. Gaseous Waste Management System

1. Meet 10CFR 20 and 10CFR 50 Appendix d
   a. Off site annual doses less than 5 mrem WB or 15 mrem skin
   b. Particulate annual dose commitment less than 15 mrem, and organ
   c. Include all cost-effective controls
   d. Meet 10CFR 20 limits
2. Capacity meets requirements
3. Seismic and quality requirements
4. Operability, Maintainability and leakage control
5. HEPA filter and Charcoal adsorbers testing, etc. RG 1.140
6. Withstand or prevent H explosion
   a. Withstand means 20 times operation pressure
   b. Prevention requires dual gas analyzers, alarmed

D. Solid Waste Management Systems

1. Adequate capacity based on experience and source terms
2. Solidify all wet wastes before shipment
3. Shipping containers meet 10CFR 71

4. Adequate on site storage
5. Piping meets criteria for liquid systems

E. Monitoring and Sampling Systems

1. Sample of Monitor all releases
2. Sample of Monitor all tanks prior to release
3. Sample of Monitor in accordance with GDC 63
   a. Representative samples
   b. Central collection point for leakage and exposure control
   c. Proper disposal of samples
4. Instrumentation, frequency, set points etc. meet RG 1.21 (FSAR)
5. Isolation valves fail closed
6. Monitor releases is postulated accidents; RG 1.97 and Draft ANSI Standard N13/42 WG6
7. Liquid releases automatically terminated if limits exceeded

FATALITIES IN SOME MAJOR DISASTERS

Natural Disasters

Epidemic and Famine	
Bubonic Plague, Europe 1340's	25 million
Influenza, World, 1917-1919	25 million
Influenza and famine, Russia 1914-24	20 million
Floods and Storms	
China, 1851-66	40 million
China, 1887	1.5 million
Holland, 1530	.4 million
Earthquake	
China, 1556	830 thousand
China, 1976	655 thousand
India, 1737	300 thousand
Fire	
Moscow, 1570	200 thousand
Japan, 1923 (earthquake)	140 thousand
Tokyo, 1857 (earthquake)	107 thousand
Avalanche and Landslide	
China, 1920	180 thousand
Tyrol, 1915-18	40 to 80 thousand
Peru, 1962 (worst single)	4 thousand

Volcano	
Unsen, Japan, 1793	53 thousand
Krakatoa, 1883	40 thousand
Pelee, Martinique, 1902	33 thousand
Technological	
Marine	
Spanish armada, 1588	4 to 10 thousand
Royal Navy, 1782	3.5 thousand
St. George and Defiance 1811	2 thousand
Explosion	
Gunpowder, Brescia 1969	3 thousand
Ammunition, China, 1935	2 thousand
Ammunition, Belguim, 1918	1.8 thousand
Mine	
Manchuria, 1931	3 thousand
Manchuria, 1942	1549
France, 1906	1060
Rail	
Spain, 1944	650
France, 1917	550
Italy, 1944 (Suffocation)	521
West Pakistan, 1957	300
Aircraft	
Boeing 747's Canary Islands, 1977	582
DC-10, Paris, 1974	346
DC-8, Sri Lanka, 1974	191
Radiation Associated	
Theoretical	
1957 Calculation (WASH 740), Maximum	3400
1957 Calculations (WASH 1400)	1400
Real	
Cleveland, 1925, X-ray film fire	125
Mexico, 1960, Lost Co-60 source	5
Idaho, 1961, SL-1 accident	3

(From: C.A. Willis, *J. Korean Nuclear Society*, March 1975, Revised)

REFERENCES

1. PNPP-1 Preliminary Safety Analysis Report, Chapter 11.
2. NUREG-75/087 Standard Review Plan
   - 11.1 Source Terms
   - 11.2 Liquid Waste Management Systems
   - 11.3 Gaseous Waste Management Systems
   - 11.4 Solid Waste Management Systems
   - 11.5 Process and Effluent Radiological Monitoring and Samplign Systems

   Branch Technical Position ETSB 11-1 (Rev. 1) "Design Guidance for Radioactive Waste Management Systems Installed in LWC NPP"

   BTP 11-3 (Rev. 1) "Design Guidance for Solid Radioactive Waste Management Systems Installed in LWC NPP"
3. Regulatory Guides
   - 1.21 "Measuring, Evaluating and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from LWC NPP" (wet with exception)*
   - 1.97 "Instrumentation for LWC NPP to Acess Plant Conditions During and Following an Accident" (alternative under review)*
   - 1.112 "Calculation of Releases of Radioactive Materials in Liquid Effluent from LWC Power Reactors" (met in ER)*
   - 1.140 "Design, Testing and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and adsorption Units of LWC NPP" (not addressed)*
   - 1.143 "Design Guidance for Radioactive Waste Management Systems, Structures and Components in LWC NPP" (not addressed)*
   - 4.15 "Quality Assurance for Radiological Monitoring Programs (Normal Operation) — Effluent Streams and the Environment" (not addressed)*
4. General Design Criteria
   - 60. "Control of Releases of Radioactive Material to the Environment"
   - 63. "Monitoring Fuel and Waste Storage"
   - 64. "Monitoring Radioactive Releases"

* Degree of Compliance on PNPP-1.

5. NUREG Reports

   0016 "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors" (BWR GALE Code)

   0017 "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressureized Water Reactors" (PWR GALE Code)

6. Regulations

   10 CFR 20. "Standards for Protection Against Radiation"

   10 CFR 50. "Licensing of Production and Utilization Facilities"
   Appendix A. "General Design Criteria for NPP" (PAEC Reg. Appendix B)
   Appendix I. "Numerical Guides for Design Objectives and Limiting Conditions to Meet the Criterion 'as Low as Practicable for Radioactive Material in LWC NPR Effluents"

   10 CRF 51. "Licensing and Regulatory Policy and Procedures for Environmental Protection" (PAEC Environmental Guide)

   10 CFR 71. "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions"

7. American National Standards Institute (ANSI) Standards
   ANSI-N 13.1-169, "Guide to Sampling Airborne Radioactive Material in Nuclear Facilities."

   ANSI-N 13/42 WG6, Draft, "Performance Specifications for Reactor Emergency Monitoring Instrumentation (1974)

   ANSI N13.10-1974, "Specification and Performance of On-site Instrumentation for Continuously Monitoring Radioactivity in Effluents"

   ANSI N137 draft "Source Term Specifications," April 1976

8. WCAP-8253 Rev. 1 "Source Term Data for Westinghouse Pressurized Water Reactors," June 1974

REFERENCES

1. Peter Beckmann, *The Health Hazards of NOT Going Nuclear*, Golem Press, Boulder, Colo. U.S.A. 1976

2. B. Cohen, "Environmental Hazards of Radioactive Waste Disposal," *Physics Today*, Vol. 29, No. 9, Jan. 1976

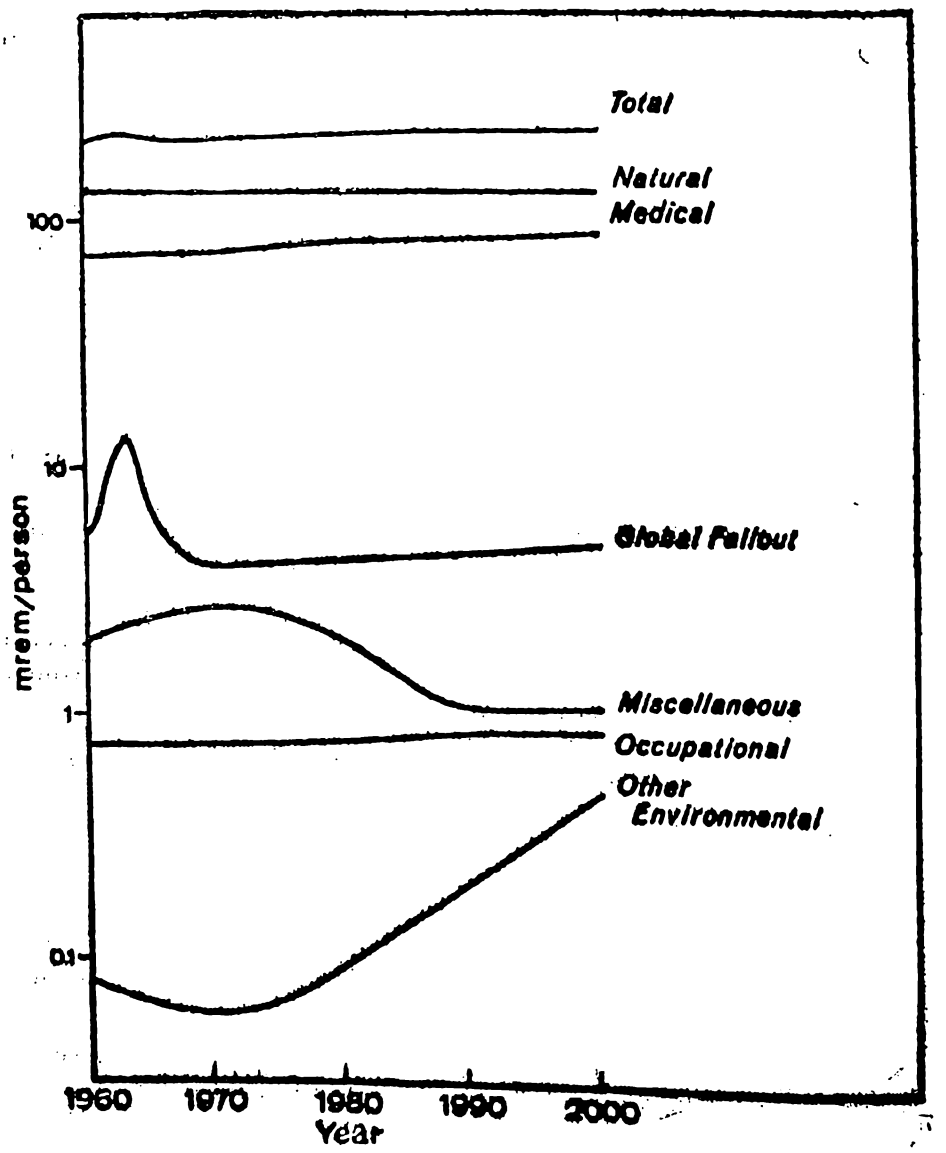
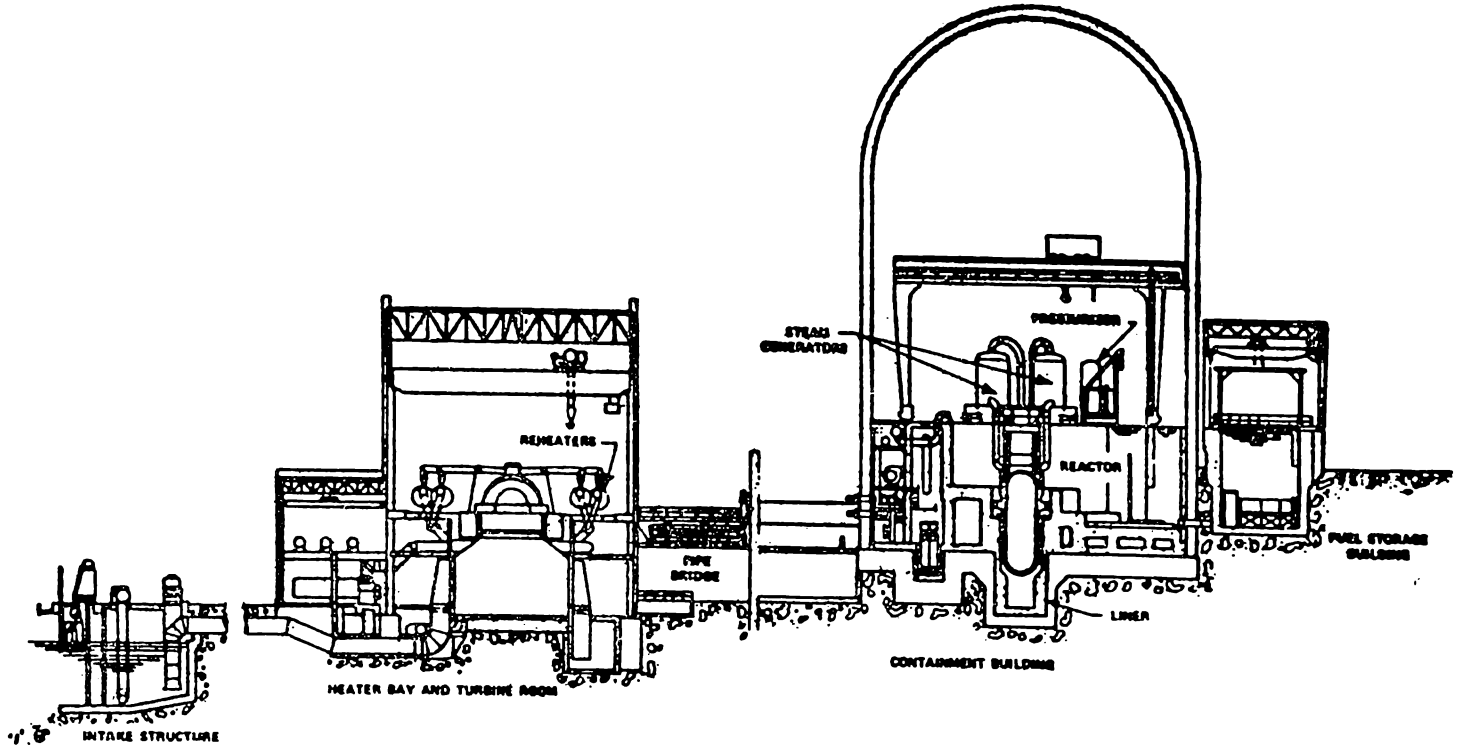
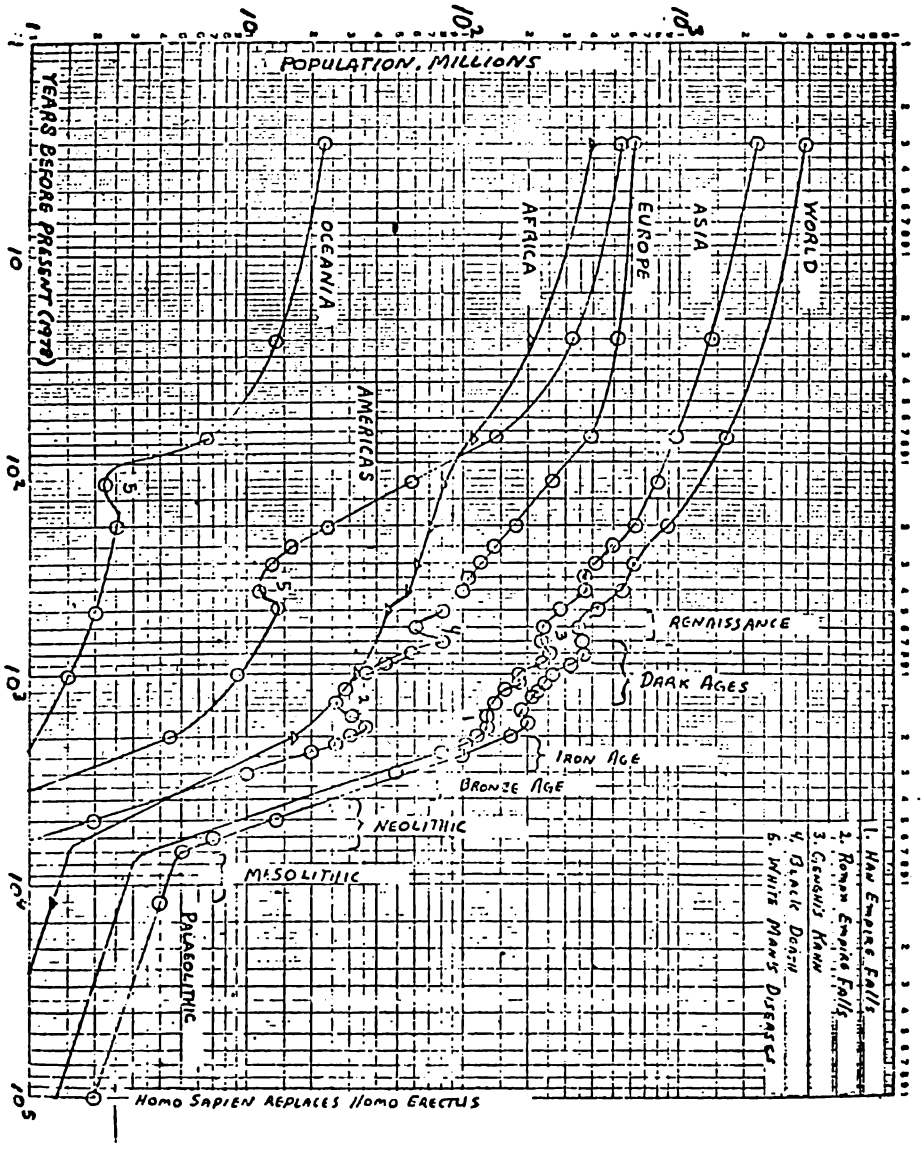


FIG. VI-2. *Summary of Estimated Average Whole-body Radiation Doses in the United States (m rem/person).*



Cross Section of a Typical PWR Plant


POPULATION, MILLIONS
YEARS BEFORE PRESENT (1970)
OCEANIA
AMERICAS
AFRICA
EUROPE
ASIA
WORLD
RENAISSANCE
DARK AGES
IRON AGE
BRONZE AGE
NEOLITHIC
MESOLITHIC
PALAEOLITHIC
HOMO SAPIEN REPLACES HOMO ERECTUS
1. HAN EMPIRE FALLS
2. ROMAN EMPIRE FALLS
3. GENGHIS KHAN
4. BLACK DEATH
5. WHITE MAN'S DISEASES

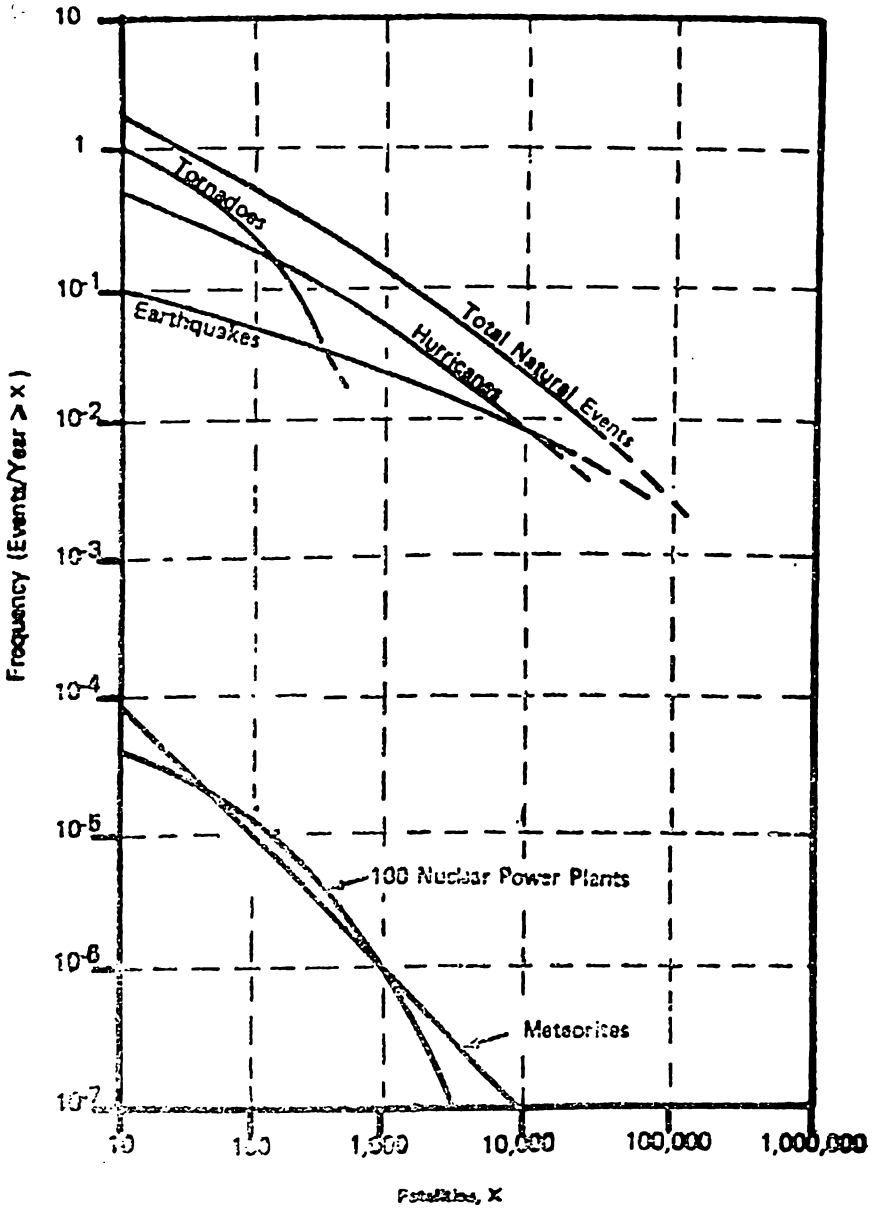


FIG. 6-2. *Frequency of Natural Events Involving Fatalities.*