LILCO, October 12, 1982

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)
	)
LONG ISLAND LIGHTING COMPANY	) Docket No. 50-322 (OL)
	) (Emergency Planning --
(Shoreham Nuclear Power Station, Unit 1)	) Phase I)
	)

TESTIMONY OF JOSEPH S. BARON, MATTHEW C. CORDARO, NICHOLAS J. DI MASCIO, JOHN N. HAMAWI, LOUIS P. POCALUJKA, AND JOHN F. SCHMITT ON BEHALF OF THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION EP 14 -- ACCIDENT ASSESSMENT AND DOSE ASSESSMENT MODELS

PURPOSE

The purpose of this testimony is to respond to Suffolk County's Contention EP 14, which contends that the methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences of a radiological emergency condition do not comply with the requirement of 10 C.F.R. § 50.47(b)(9) that they be "adequate." This testimony describes the dose model equations used to calculate projected offsite doses, and also shows that the assessment instrumention that provides the data to these dose models is adequate.

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Attachments to this Testimony:

14-1	Resume of Dr. Joseph S. Baron
14-2	Resume of Matthew C. Cordaro
14-3	Resume of Nicholas J. Di Mascio
14-4	Resume of Dr. John N. Hamawi
14-5	Resume of Louis P. Pocalujka
14-6	Resume of John F. Schmitt
14-7	SP 69.022.01
14-8	Description of dispersion and dose assessment models

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Q1. Will the witnesses please identify themselves?

A1. [Baron] My name is Joseph S. Baron. My business address is Stone & Webster Engineering Corporation, 245 Summer Street, Boston, Massachusetts 02107. A copy of my professional qualifications is attached (Attachment 14-1). As Power Engineer I am responsible for the procurement of a calibrated radiation-monitoring system at Shoreham. My role on this witness panel is to address the radiological instrumentation equipment which interfaces with the dose assessment software.

[Cordaro] My name is Matthew C. Cordaro. I am Vice President, Engineering for LILCO. My business address is 175 East Old Country Road, Hicksville, New York 11801. A copy of my professional qualifications is attached (Attachment 14-2). My role in emergency planning is to ensure that LILCO's emergency planning needs are being met and that management is kept apprised of emergency planning needs and problems.

[Di Mascio] My name is Nicholas J. Di Mascio. My business address is Long Island Lighting Company, Shoreham Nuclear Power Station, P.O. Box 628, Wading River, New York 11792. I am a Plant Engineer, Health Physics Section, employed by LILCO at the Shoreham Station. A copy of my professional qualifications is attached (Attachment 14-3). My knowledge about this contention is based on my being involved with the emergency dose calculation methods and my coordination of the on-site emergency planning effort.

[Hamawi] My name is John N. Hamawi. I am President of Entech Engineering, Inc., which supplied the atmospheric dispersion and dose model equations that have been incorporated into the Shoreham Effluent Monitoring Software Package (EMSP). My business address is J&N Professional Building - 18 Lyman Street, Westborough, Massachusetts 01581. A copy of my professional qualifications is attached (Attachment 14-4).

[Pocalujka] My name is Louis P. Pocalujka. I work for TRC Environmental Consultants, Inc., 800 Connecticut Boulevard, East Hartford, Connecticut 06108. My position with the company is Manager, Air Monitoring Projects/Senior Project Scientist. A copy of my resume with professional qualifications is attached (Attachment 14-5). My familiarity with the meteorological monitoring system at LILCO's Shoreham Station results from TRC's contract to update the primary meteorological tower there. The proposal, system design, and installation were conducted by TRC's Air Monitoring Projects personnel, reporting to me.

[Schmitt] My name is John F. Schmitt. My business address is Long Island Lighting Company, Shoreham Nuclear Power Station, P.O. Box 628, Wading River, New York 11792. I am the Radiochemistry Engineer at Shoreham. A copy of my professional qualifications is attached (Attachment 14-6). My knowledge about this contention is based on my familiarity with (1) the radiation monitoring system and (2) the effluent quantification and dose calculation methods we employ.

Contention and Regulations

Q2. What is Contention EP 14?

A2. [Di Mascio] Contention EP 14, as revised by the Atomic Safety and Licensing Board in its Order of September 7, 1982, reads as follows:

> EP 14: ACCIDENT ASSESSMENT AND DOSE ASSESSMENT MODELS
> (SC, joined by SOC and NSC)
>
> LILCO's plan fails to provide reasonable assurance that adequate methods, systems and equipment for assessing and monitoring actual or potential off-site consequences of a radiological emergency condition are in use, and therefore does not comply with 10 CFR §50.47(b)(9).

Q3. What does 10 C.F.R. § 50.47(b)(9) say?

A3. [Di Mascio] Section 50.47(b)(9) reads as follows:

> (b) The onsite and offsite emergency response plans for nuclear power reactors must meet the following standards [footnote omitted]:
>
> . . . .
>
> (9) Adequate methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences of a radiological emergency condition are in use.

Q4. What is the crux of the contention, as you understand it?

A4. [Baron, Di Mascio, Schmitt] As best we can determine, judging mainly from early drafts of the contention and from the deposition of Suffolk County's consultant, Mr. Gregory C. Minor, the contention raises two concerns: first, that the radiological monitoring equipment used to provide data for the dose projection calculations may be inadequate in some unspecified way; second, that the dose model equations for calculating the offsite doses may be inadequate. In addition, Mr. Minor has indicated that he may raise concerns about unspecified equipment having to do with meteorology. Accordingly, we have addressed in this testimony certain meteorological monitoring equipment.

We judge, however, that this contention does not cover the equipment of the field monitoring teams or the iodine monitoring equipment, since those are the subject of parts (A) and (C) respectively of a separate contention, EP 10, "Accident Assessment and Monitoring." If the County had wished to raise additional contentions about field monitoring equipment or iodine monitoring equipment, presumably it would have done so in EP 10. Additionally, instrumentation used in monitoring the course of an accident and post-accident assessment is specified in Reg Guide 1.97 (Rev. 2). This instrumentation was at issue in SOC contention 3/SC contention 27. We have therefore concluded that, except for those issues that were deferred to later contentions, equipment specified by Reg Guide 1.97 (Rev. 2) is not at issue here.

Notwithstanding what we have just said, we believe that the Board's admission of Contention EP 14, speaking as it does of "equipment," may represent a decision that to a limited extent instruments covered by Reg Guide 1.97 may now be litigated. Accordingly, in this testimony we discuss certain instruments, covered by Reg Guide 1.97, that provide data for the dose projection calculations.

We infer, however, that the County's principal concern under EP 14 is the offsite dose assessment model equations. The original contention (then designated EP 27) as found in the County's "First Amended Consolidated Emergency Planning Contentions," dated July 6, 1982, asserted that LILCO had not provided the basis for "the accident assessment and dose assessment models" (emphasis added). The restatement of the contention in the County's July 12, 1982 "Response of Suffolk County to Objections of LILCO and of NRC Staff to First Amended Consolidated Emergency Planning Contentions" contains as its central proposition that LILCO has not ensured "the accuracy of the assessment models" (emphasis added).

Equipment

Q5. What equipment does this contention cover?

A5. [Baron, Schmitt] The post-accident radiation monitors used to support the dose calculations or to assess potential releases during a radiological accident are the only equipment that we believe relate to this contention.

Q6. What radiological equipment would be used to assess and monitor the actual or potential offsite dose consequences of a radiological emergency condition?

A6. [Baron, Schmitt] Assessment and monitoring of actual and potential offsite consequences of a radiological emergency condition are based on inputs from the radiation monitors in the Station Vent Exhaust and RBSVS Exhaust. The assessment and monitoring of potential offsite consequences of a radiological condition are also based on inputs from radiation monitors in the primary containment.

Q7. Why do you believe these monitors are adequate to provide data for use with dose projection calculations or to assess potential releases during a radiological accident?

A7. [Baron, Schmitt] The monitors in question are overlapping-range noble gas monitors and an iodine sampling system on the station vent, overlapping-range noble gas monitors and an iodine sampling system on the RBSVS, and two high range area radiation monitors inside the primary containment.

Current NRC guidance regarding these post-accident radiation monitors is NUREG-0737 and Reg Guide 1.97 (Rev. 2). With the exception of the low range noble gas detector on the station vent, these monitors meet the design guidance of these documents. The low range station vent monitor is part of the station vent nonaccident effluent monitoring system and was not originally purchased with seismic or environmental qualification. The power supply for this detector has been upgraded to meet the "highly reliable power supply" requirements of Reg Guide 1.97 (Rev. 2). In the NRC staff recommendations attached to SECY 82-111 the staff states (page 13):

> It is acceptable to rely on currently installed equipment if it will measure over the range indicated in Regulatory Guide 1.97 (Rev. 2), even if the equipment is presently not environmentally qualified. Eventually, all the equipment required to monitor the course of an accident would be environmentally qualified in accordance with the pending Commission rule on environmental qualification.

We believe that these monitors are adequate to provide data for use with dose projection calculations or to assess potential releases during a radiological accident. The monitor ranges are very broad and cover "worst case" types of accidents. The ranges are:

Station Vent Exhaust	10^{-6} to 10^{+4} μCi/cc
RBSVS Exhaust	10^{-6} to 10^{+4} μCi/cc
Primary Containment	1 to 10^{+7} rad/hr

Q8. Do you have any feel for what Suffolk County may think is inadequate regarding the monitors' support of the dose calculations or potential release assessment during a radiological accident?

A8. [Baron, Schmitt] No.

Q9. Is other equipment covered by this contention?

A9. [Baron, Schmitt] Mr. Minor said, on page 85 of his deposition, that he would "look at all equipment that would be relied on to assess the development of the accident which would not be just radiation monitoring." In light of the fact that he had as of that date identified no specific equipment and still has not, so far as we know, until the date of filing of this testimony, we do not believe any other equipment (with the possible exception of meteorological instrumentation used in plume prediction, discussed below) is fairly within this contention.

The only indication we have that the County may be concerned about meteorology equipment is in Mr. Minor's deposition transcript (page 73), where he says that he "may" investigate some of the equipment "which has to do with possibly -- I don't want to say for sure -- but possibly the meteorology and possibly the modeling that's used in the plume prediction." We have previously litigated contention SC 27/SOC 3 concerning post accident instrumentation as contained in Reg Guide 1.97 (Rev. 2), which includes meteorological monitoring equipment, and so such equipment is not properly at issue in this contention.

Q10. Please list the meteorological parameters used to calculate doses.

A10. [Hamawi] Wind speed and direction at 150 feet and at 33 feet, temperature at 33 feet, and the difference in temperature between the 150- and 33-foot levels.

Q11. What equipment at Shoreham will provide these parameters?

A11. [Pocalukja] The system designed for LILCO provides the basic input parameters required to perform dispersion analyses, namely, wind speed, wind direction and stability in the form of temperature difference (ΔT) and standard deviation of horizontal wind direction ($\sigma\theta$). The meteorological sensors and translator cards are designed and manufactured by Climatronics. The analog recorder systems are designed and manufactured by Esterline-Angus.

Q12. Is this system adequate?

A12. [Pocalujka] Yes. The equipment is of standard design and similar to systems in use at other nuclear sites. The design specifications of the hardware conform to the guidance provided by USNRC Regulatory Guide 1.23 and the proposed Revision 1 to Regulatory Guide 1.23.

Dose Assessment Methods

Q13. Referring back to Contention EP 14, will you tell the Board what "methods" you plan to use for dose assessment?

A13. [Di Mascio, Schmitt] The "methods" consist of real-time computerized models and, as a backup, hand calculations as described in procedure SP 69.022.01, "Determination of Offsite Doses" (Attachment 14-7).

Q14. Let's first talk about the computer software used to calculate projected offsite doses. Will you please describe this software for the Board?

A14. [Di Mascio, Hamawi, Schmitt] The computer software that is used to evaluate the offsite radiological impact of radioactive effluents from the Shoreham Station is known as Effluent Monitoring Software Package (EMSP). The EMSP module that performs the dose-assessment analyses under accident conditions is called "ACC."

ACC carries out dose calculations in two fashions: (a) once every minute using short-term accident dispersion models and (b) once every hour using long-term dispersion models. The short-term analyses include the determination of offsite thyroid and wholebody gamma dose rates as a function of downwind distance from the plant. The long-term analyses consider not only the airborne radioactivity but also the radioactivity deposited on the ground along with the ingestion and inhalation pathways, and dose exposures are determined for the site boundary, the nearest residence, the nearest garden, and the nearest cow in the affected downwind sectors. For the short-term analyses, which form the basis for the implementation of emergency actions, the radionuclides considered are the halogens and the noble gases. The long-term scenario also includes an extensive list of particulates.

Two effluent release pathways are considered at all times: the station vent and the Reactor Building Standby Ventilation System (RBSVS) exhaust. The isotopic inventories for each release pathway are entered into the software manually following completion of grab-sample analyses in the laboratory, plant-specific default inventories being available for use at the start of an accident. The release rates to the atmosphere are adjusted every minute based on the prevailing air flow rate at each release point and the relative change in the effluent radiation monitor readings.

Real-time meteorological data are updated every 15 minutes for the short-term analyses and every hour for the long-term case.

Q15. Would you please describe the output of the accident module of the EMSP software which provides an assessment of the offsite radiological impact?

A15. [Di Mascio, Hamawi] The ACC module provides the following output for emergency use:

a. Wholebody gamma and thyroid dose rates at the exclusion radius, the site boundary, 0.5 mile, 1 mile, 2 miles, 3 miles, 4 miles, 5 miles and 7.5

miles in the affected downwind sector (hard printer copy, automatically every minute),

b. Video display plots, on demand, which consist of user-selected scaled maps of the affected region (2-, 5-, or 10-mile ranges) with superimposed isodoserate contours of user-specified levels (wholebody and thyroid radiation exposure rate levels are plotted separately),

c. Printer plots, on demand, each plot presenting the downwind regions of equal radiation intensity (up to 5 regions), the dose rates as a function of distance from the plant, the plume travel time, and the off-centerline distance at which the various dose rates are attained (20-mile maximum downwind distance).

d. A video-display bar-graph plot of the downwind plume-centerline dose rates (wholebody or thyroid) at the exclusion radius, site boundary, 0.5 mile, 1, 2, 3, 4, 5, 10, 20 and 50 miles at a user-specified time within the last 180 minutes of the accident.

e. A video-display bar-graph plot of total cumulative doses versus distance since the start of the accident for a user-specified downwind sector,

f. A video-display plot of the dose rates or total doses versus time using the most recent 120 minutes of data from the dose files for a user-specified distance and sector, and

g. A video-display plot of dose-projection for a user-specified sector and distance which consists of the last 60 minutes of dose rate or dose data with a calculated linear projection 60 minutes into the future along with its prediction error.

Q16. Dr. Hamawi, did you develop any portion of the EMSP software?

A16. [Hamawi] Yes. The EMSP software was developed by Nuclear Measurements Corporation. I was retained by LILCO to upgrade the atmospheric dispersion software to include the new models in Regulatory Guide 1.145, and to incorporate finite-cloud gamma dose assessment models from overhead plumes. Incorporation of the finite cloud model has also necessitated revisions to the plot routines.

Q17. Please describe briefly the atmospheric dispersion and dose-assessment models you have incorporated into the EMSP software.

A17. [Hamawi] A detailed description of the models is given in Attachment 14-8 to this testimony. Briefly, the dispersion and dose equations represent combinations of various models available in the regulatory guides and other standard references (in particular Reg Guides 1.109, 1.111, and 1.145; Meteorology and Atomic Energy - 1968; and Turner's Workbook on Atmospheric Dispersion Estimates). What is of interest in the models described in Attachment 14-8 is the definition of two different atmospheric dispersion factors, the "concentration (χ/Q)" and the "gamma (χ/Q)." The "concentration (χ/Q)" is the standard (χ/Q) factor representing the relative concentration of radioactive material at ground level at a receptor of interest. The "gamma (χ/Q)" is a refined concept which can be used in place of the standard (χ/Q) to transform the wholebody gamma dose rate equations for semi-infinite clouds to those for finite clouds. Definition of this new parameter was arrived at by simply restructuring the finite-cloud dose rate equations available in the literature. But unlike the standard (χ/Q), the gamma (χ/Q) is a function not only of wind speed, plume dimension, and elevation, but also of the normalized gamma spectrum corresponding to the airborne radioactivity. The influence of the gamma spectrum on the gamma (χ/Q) is not very strong, and diminishes with increases in the size of the plume. For very large plumes, the numerical value of the gamma (χ/Q) reduces to that of the concentration (χ/Q), as would be expected. For close-in receptors and elevated plumes, the gamma (χ/Q) will always have a finite non-zero number, whereas the ground-level concentration may very well be zero.

Q18. Have your equations been used at other nuclear power plants?

A18. [Hamawi] Yes. My atmospheric dispersion and dose-assessment equations are used at the following nuclear power plants:

- Seabrook (FSAR)
- Charlestown (PSAR)
- Maine Yankee (Stretch Power Application)
- Pilgrim Station (Emergency Plan)
- Vermont Yankee (Emergency Plan)
- Yankee Rowe (Emergency Plan)

Q19. Please tell the Board in what way your dose-assessment model is a refinement of the standard equations.

A19. [Hamawi] The dispersion and dose equations are standard, as explained earlier. They have merely been mathematically restructured into forms which are easier to understand and apply, and which reduce the numerical computations.

The numerical integration scheme which I developed for the sector-average finite cloud model is presently included in Reg Guide 1.109. The finite-cloud sector average model is that described in Meteorology and Atomic Energy - 1968. It is that model, along with the Gaussian puff model in the same reference, that has been incorporated into the EMSP software.

Q20. Do your dose model equations comply with current regulatory guidance?

A20. [Hamawi] Yes.

Q21. What happens if the RMS computer is not working?

A21. [Di Mascio, Schmitt] Then the offsite dose calculations can be done by hand using Emergency Plan Implementing Procedure SP 69.022.01 (Attachment 14-7), which uses the same dose assessment equations.

Q22. Are your dose equations adequate for assessing doses from radioactive plumes resulting from radiological emergency conditions?

A22. [Hamawi, Di Mascio] Yes.

Q23. Do you consider the assessment and monitoring equipment which input to the dose projection models to be adequate?

A23. [Schmitt, Baron, Pocalujka] Yes.

Q24. Do the methods, systems, and equipment discussed in this testimony comply with 10 C.F.R. § 50.47(b)(9)?

A24. [Di Mascio, Baron, Hamawi, Pocalujka, Schmitt] Yes.

PROFESSIONAL QUALIFICATIONS

JOSEPH S. BARON

Power Engineer, Nuclear Engineering Group

STONE & WEBSTER ENGINEERING CORPORATION

My name is Joseph Baron. My business address is 245 Summer Street, Boston, Massachusetts 02107. I am employed by Stone & Webster Engineering Corporation (SWEC) as a Power Engineer and have held this position since January 1973. In this capacity I am currently responsible for the radiation monitoring system for the Shoreham Nuclear Power Station - Unit 1 Project.

I was awarded a Bachelor of Science degree in chemical engineering in 1966, dual Master of Science degrees in chemical and nuclear engineering in 1968, and a Ph.D. in nuclear engineering in 1971, all by Massachusetts Institute of Technology.

Prior to joining SWEC in August 1971, I worked as a part-time Assistant Process Engineer for Diamond Shamrock Company in Cleveland, Ohio. I was responsible for the evaluation of chemical kinetics data, development of a workable kinetics model for use in the design of a production chemical reactor and design of scrubbing towers. Later as a Research

Associate with Argonne National Laboratory, I established the setup and calibration of an analytical system for the determination of inpurities in sodium. Next, with Oak Ridge National Laboratory as a Research Associate (August 1967 - February 1968), I was responsible for the design of an accurate method of determining the thermal flux history of the irradiaton cavity of the high flux isotope reactor, for feasibility and kinetic studies in the use of amines as dehydrating agents in the microsphere production step of the Sol-Gel process; analysis of the electrical charge distribution in a metallic aerosol; and preparation of reactor physics data for use in an economic evaluation of a high temperature gas-cooled reactor (HTGR). From February 1968 - August 1971 I was involved in resident study toward my doctorate degree.

Upon joining SWEC in August 1971 as an Engineer in the Nuclear Division, I functioned as an Assistant Supervisor in charge of the design and development of light water reactor (LWR) radioactive waste systems as well as specialist in ion exchange. In this capacity, I interacted with technical staff members involved in other plant systems in an effort to minimize potential radioactive releases. I supervised the simulation group which developed computer models for the operation of radioactive waste systems and for plant effluent releases, both steady state and transient. On assignment to the Boston Edison Pilgrim Project, I participated in the conceptual development of alternate radioactive waste processing capability. I was also involved in the evalation of the existing equipment, and systems to determine the long-term viability. Another activity concerned determination and development of various accident scenarios for the liquid metal fast breeder reactor (LMFBR) prototype project.

On the Wisconsin Utilities Project as Principal Nuclear Engineer (February 1978 - July 1979) I was responsible for all nuclear steam supply system (NSSS) interfaces and the design of systems in the reactor portion of the plant. I participated in the development of site specific potential accident sequences. On temporary assignment to Virginia Electric and Power Company's Surry project, I assisted in coordinating the proposed primary coolant hot magnetic filter retrofit, which was not installed.

As Principal Nuclear Engineer on the SWEC sponsored Reference Nuclear Power Plant (July 1979 - May 1980), I ensured that systems designs within the reactor portion of the plant met applicable interface criteria for the various pressurized water reactor (PWR) NSSS vendors and developed generic systems descriptions. I participated in the design and development of the concept of the Independent Fuel Storage Facility.

Later, as Lead Nuclear Process Engineer on the Nuclear Power Company, Ltd. (NPC), Project (April 1980 - May 1981), I was responsible for the development of the Civil Demonstration

Fast Reactor Cover Gas System design. Additionally, I coordinated design and structural activities for the NPC efforts within the London and Boston offices.

I was also responsible for developing an economical and efficient method of cleaning the reactor coolant of a boiling water reactor following an inadvertent injection of sodium pentoborate. A constraint was using existing plant equipment. This involved simulation of the various operations to determine the rate limiting step; the development and sequencing of the process to minimize the impact of this step was an integral part of the study for Toyo Engineering, Japan.

Additionally, I was engaged in development of the conceptual process design for a coal slurry dewatering and storage facility. Although a generic design was being developed, specific application was for the Nevada Power and Light Company.

Since assigned as a Power Engineer on the Shoreham Nuclear Power Station - Unit 1 (SNPS-1) Project (May, 1981), I am responsible for securing a workable and calibrated radiation monitoring system. This will be achieved through the support of experience in the design and construction of test apparatus, planning experiments and analyzing accumulated data.

I am a Registered Professional Engineer in Massachusetts and a member of the following technical societies: The American Institute of Chemical Engineers, the American Nuclear Society, The American Nuclear Society's

Standards Groups developing design criteria for Gaseous and Liquid Radioactive Waste Systems for Light Water Reactors, Sigma Xi - Honorary Research Society, Tau Beta Pi - Honorary Engineering Society and Phi Lambda Upsilon - Honorary Chemical Society.

Publications include "Upper-Bound Cost/Benefit Analysis under Appendix I for a Hypothetical Pressurized Water Reactor," J.S. Baron and R.M. Vanasse, presented at the ANS Toronto meeting in June 1976; and "Treatment of Liquid Wastes," Chapter 6, Nuclear Power Waste Technology, J.S. Baron and B. V. Coplan, ASME (1978).

PROFESSIONAL QUALIFICATIONS

MATTHEW C. CORDARO

Vice President of Engineering

LONG ISLAND LIGHTING COMPANY

My name is Matthew C. Cordaro. My business address is Long Island Lighting Company, 175 East Old Country Road, Hicksville, New York 11801. I am currently Vice President of Engineering and have held this position since the spring of 1978. As Vice President of Engineering, I am responsible for all of LILCO's engineering activities. This includes responsibility in the areas of facility planning and engineering for nuclear and fossil electric generating plants, as well as electric and gas transmission and distribution systems. In addition, I am responsible for assessing the environmental impacts of all LILCO operations.

I received my Bachelor of Science degree in Engineering Science from C. W. Post College in 1965. I received my Master of Science degree in Nuclear Engineering from New York University in 1967. I received my Doctorate in Applied Nuclear Physics from the Cooper Union School of Engineering and Science in 1970. I was awarded the Atomic Energy Commission Special Fellowship in Nuclear Science and Engineering.

My past professional affiliations include a position as Guest Research Associate at Brookhaven National Laboratory, Adjunct Associate Professor of Nuclear Engineering at Polytechnic Institute of New York and Adjunct Assistant Professor at C. W. Post College.

I joined LILCO in 1966 and from 1966 to 1970 I held the positions of Assistant Engineer (1966), Associate Engineer (1967), Nuclear Physicist (1968) and Senior Environmental Engineer (1970). In these earliest positions with LILCO I was involved as a principal in all phases of nuclear power plant design, licensing and fuel management. I was also a lead witness for the Company in Federal and State licensing proceedings for the Shoreham and Jamesport Nuclear Power Stations.

In 1972 I assumed the position of Manager of Environmental Engineering. In this capacity I was responsible for the environmental impact of all LILCO operations. This position involved the supervision, administration and direction of all environmental programs aimed at demonstrating compliance with applicable standards.

I am a member of a number of related professional organizations including: the Board of Directors, Adelphi University's Center on Energy Studies; and the Council of Overseers, C. W. Post College. Other related professional numerous studies and reports related to the environmental effects of energy production.

I recently testified before Congressional Committees on Nuclear Waste Transport and the Economics and Environmental Impacts of Coal Utilization.

PROFESSIONAL QUALIFICATIONS

NICHOLAS J. DiMASCIO

Nuclear Plant Engineer - Health Physics Sections

LONG ISLAND LIGHTING COMPANY

My name is Nicholas J. DiMascio and my business address is Long Island Lighting Company, Shoreham Nuclear Power Station, Post Office Box 628, Wading River, New York 11792. I have been Assistant Health Physics Engineer at the Shoreham Nuclear Power Station since October 1978. In this capacity I am responsible for the development of many station radiation protection programs and activities.

I was initially assigned the responsibility of developing a specification for the purchase of a combined Whole Body Counting and Ge(Li) Isotopic Analysis System. My other duties include: supervision of the Health Physics Technicians; preparation of Health Physics procedures; development of a computerized Dose Records Keeping System; establishment of a Respiratory Protection Program which meets the requirements of Regulatory Guide 8.15 and NUREG-0041; initiation of a TLD System; preparation of Emergency Plan and site Emergency Plan Implementing Procedures for compliance with guidance of

NUREG-0654 Rev.1; and assisting the Health Physics Engineer as required.

I was awarded my Bachelors degree in Radiological Health Physics in 1974 from Lowell Technological Institute. I subsequently attended the University of New York at Stonybrook where I worked towards a Master of Science degree in Industrial Management. I earned the last twelve credits of a Master of Science degree in Nuclear Engineering at the Polytechnic Institute of New York. In addition, I successfully completed numerous training programs ranging from four days to twelve weeks. These programs include: Boiling Water Reactor Health Physics Technology (General Electric); Basic Power Plant Systems (Stone & Webster); Various Health Physics Workshops (Health Physics Society); Boiling Water Reactor Radiochemistry Technology (General Electric); Radiological Emergency Response Coordinators Course (United States Environmental Protection Agency); and Planning for Nuclear Emergencies (Harvard School of Public Health).

From November to June 1973 I was employed by the New England Electric Company for a summer internship program. I was assigned as Health Physics Assistant at the Yankee Rowe and Vermont Yankee Nuclear Power Stations and assumed the following duties: the performance of routine surveys and analyses; the use of radiation sources for the calibration of portable survey instrumentation; the provision of health physics coverage during a refueling outage at Vermont Yankee; a detailed survey of normal gaseous effluent releases at the site boundary of Yankee Rowe; and the collection of offsite environmental samples--liquid, gaseous, and ground--for analyses of annual releases from Yankee Rowe.

From June 1974 to September 1978 I was employed by Stone & Webster Engineering Company as an Engineer in the Radiation Protection Department. My duties included performing the required accident analyses, evaluating radiation safety and determining adequate shielding for systems and components within nuclear power plants. I participated in a 10 CFR Part 50, Appendix I evaluation of effluent releases for Millstone Units 1 and 2. I developed specification for a digital radiation monitoring system for the Shoreham Nuclear Power Station as well as determining detector setpoints for the radiation monitoring system at North Anna Units 1 and 2. While still an employee at Stone & Webster, I was assigned to LILCO as a consultant at the Shoreham Nuclear Power Station for approximately fifteen months to assist the Health Physics Engineer in preoperational planning and procedure development.

Since October 1978 I have been a LILCO employee and, more specifically, have been assigned to the Shoreham Operating Staff as a Nuclear Plant Engineer in the Health Physics Section. During this period I have been assigned to On-Site Training I and II and training at Vallecito's Nuclear Training

Center commensurate with performing duties with the position of Assistant Health Physics Engineer. On-Site Training I included formal classroom lectures on components and operation of systems at the Shoreham Nuclear Power Station. On-Training II involved classroom lectures on operating procedures of each section of the Plant Staff, and familiarization of several emergency operating procedures. My assignment at General Electric's Vallecito's Nuclear Training Center included intensive formal classroom theory on BWR Health Physics Technology and practical applications through actual performance of normal routine surveys and calibrations.

I am a member of the Health Physics Society and the Greater New York Chapter of Health Physics Society.

My experience with radiation is extensive. In time increments ranging from twelve weeks to two years, I gained experience at Vermont Yankee, Yankee Atomic, Stone & Webster, General Electric and Lowell Technological Institute working with isotopes and their related types of uses. This experience included working with Co-60 and Cs-137 isotopes for calibration and check sources; mixed corrosion, mixed fission, and mixed activation products isotopes for use involving reactor coolant, radwaste, plant radiation, plant contamination and class experiments; noble gases isotopes for use as gas effluent samples and class experiments; and a Tritium isotope for liquid samples usage.

The training I received at Vermont Yankee, Yankee Atomic, Stone & Webster, General Electric and Lowell Technological Institute consisted of either on-the-job or formal training sessions. Ranging from three weeks to four years, the types of training I received involved: principles and practices of radiation protection; radioactivity measurement standardization and monitoring techniques and instruments; mathematics and calculations basic to use and measurement of radioactivity; and biological effects of radiation.

PROFESSIONAL QUALIFICATIONS

JOHN N. HAMAWI

President

ENTECH ENGINEERING, INC.

My name is John N. Hamawi and my business address is Entech Engineering, Inc., 18 Lyman Street, Westboro, Massachusetts 01581. I am currently the President of Entech Engineering and have held this position since November of 1979.

I received my Doctorate degree in Nuclear Engineering from the Massachusetts Institute of Technology in 1969. From September 1963 to August 1969 I was employed in a graduate student capacity at MIT as a part-time research/teaching assistant. In this position, I gained experience in the following areas: the design, construction and/or operation of a number of experimental setups in the Plasma Physics and Reactor Physics laboratories; radiation shielding; gramma-ray spectroscopy; activation analysis; and computer programming.

From September 1969 to November 1970 I was employed by Stone & Webster Engineering Corporation in Boston, Massachusetts as an Engineer in the Radiation Protection Group. My major assignments included: the nuclear design of an industrial radiographic facility with an 8 MeV electron linear accelerator which involved shielding calculations to ensure the selection of a design that would provide adequate protection from radiation generated by the accelerator; and the development of an analytical method and computer code for evaluating the radiological impact of nuclear power reactors from postulated accidental releases.

In 1970 I joined Yankee Atomic Electric Company (YAEC), Westboro, Massachusetts. From December 1970 until September 1973 I was employed as an Engineer in YAEC's Safety Analysis Group (now Radiological). One of my major assignments involved the development of analysis and computer codes for the evaluation of: potential radiological consequences of accidents postulated to occur in light-water reactors; radiological exposure from routine radioactive effluents and finite clouds; radiation shielding; fission product generation, decay, diffusion and transport; radiolytic hydrogen generation during a postulated LOCA; body burden evaluation of power-plant personnel from in vivo measurements; and meteorological data reduction techniques (joint frequency distributions and atmospheric dilution factors). In addition, I was instrumental in applying the above methods and computer codes in the preparation of PSAR's, FSAR's and Environmental Reports.

In October 1973 I was an Engineer in the Research and Engineering Development Group at YAEC. I retained this position through November of 1974. One of my major assignments and accomplishments was the development of an analysis method for evaluating the smearing (or redistribution) of fission product decay heat between adjacent fuel rods during shutdown conditions for use in LOCA analyses. I also provided technical consultation in the Radiological Engineering Group at Yankee.

From December 1974 to October 1976 I held the position of Senior Engineer of Research and Engineering Development at YAEC. I was responsible for a project aimed at providing Yankee Atomic with a LOCA analysis capability. The project plan called for the adoption of the Water Reactor Evaluation Model (WREM) prepared by the Nuclear Regulatory Commission, and for modelling the Yankee plant at Rowe, Massachusetts, as a benchmark. I was also responsible for the development of methodology and computer codes for the determination of: (i) hourly and average atmospheric dilution factors and deposition rates of power-plant radioactive effluents for inland and coastal sites (with trapping and fumigation), and (ii) statistical distributions of dose intensity from finite clouds of accidentally released radioactive materials for use in design-basis analyses.

From November 1976 to June 1977 I was Principal Engineer in the Technical Resources Department at YAEC. My responsibilities were to provide technical input to Yankee's research and engineering development program, and to maintain an active technical/consulting role within the Yankee organization.

The last position I held at YAEC, from July 1977 to November 1979, was that of Principal Engineer in the Environmental Engineering Department. My responsibilities included providing technical consultation and developing new, state-of-the-art analytical methods and computer codes in the area of radiological engineering and atmospheric dispersion. One of my major accomplishments was to develop a method for computing the gamma dose integrals for the finite-cloud sector-average model. This method has been endorsed by the U.S. Nuclear Regulatory Commission and is presently included in Regulatory Guide 1.109.

I am a member of the American Nuclear Society and the Health Physics Society, New England Chapter.

My theses and publications include:

"Spectroscopic Measurement of Argon and Helium Excited State Densities in a Hollow Cathode Discharge", S.M. Thesis, MIT, Nuclear Engineering Department, 1964 (Prof. L. M. Lidsky, Supervisor).

"Investigation of Elemental Analysis Using Neutron-Capture Gamma-Ray Spectra", Ph.D. Thesis, MIT, Nuclear Engineering Department, 1969 (Prof. N.C. Rasmussen, Supervisor).

"Neutron-Capture Gamma Rays of 75 Elements Listed in Terms of Increasing Gamma-Ray Energy", MITNE-105, 1969 (Co-Author N.C. Rasmussen).

"A Useful Recurrence Formula for the Equations of Radioactive Decay", Nuclear Technology Vol. 11, pp. 84-88 (May 1971).

"Yankee Rowe Core XI - Decay Heat Redistribution Factor During Shutdown Conditions", YAEC-1071 (June 1974).

"Toward the Development of Yankee LOCA-Analysis Capability - Project Plan, Phase I", YAEC-1081 (Jan. 1975)

"A Method for Computing the Gamma-Dose Integrals I1 and I2 for the Finite-Cloud Sector-Average Model", YAEC-1105 (April 1976)

"AEOLUS - A Computer Code for Determining Hourly and Long-Term Atmospheric Dispersion of Power-Plant Effluents and for Computing Statistical Distributions of Dose Intensity from Accidental Releases", YAEC-1120 (Jan. 1977) (see also ANS Transaction Vol. 26, P. 123, June 1977)

"A Modified Variable Trajectory Puff Advection Model for Airborne Effluents", ANS Transaction, Volume 27, page 122. November 1977 (Co-authors J. Laznow, B. L. Drawbridge).

"SKIRON - A Computer code for Determining Atmospheric Dispersion Conditions for Design Basis Accident Evaluation", YAEC-1138, October 1977. (Also presented in ANS topical meeting on "Probabilistic Analysis of Nuclear Reactor Safety", May 8-10, 1978, Los Angeles, California). (Co-author J. Laznow).

"Comparison of the Critical-Sector and Overall-Site Atmospheric Dispersion Models". ANS Transactions, Vol. 32, Page 107, June 1979

"Comments on Regulatory Guide 1.145, 'Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," ENTECH Report P100-R1, December 1979

"DIDOS-III - A three-Dimensional Point-Kernel Shielding Code for Cylindrical Sources", ENTECH Report P100-R2, December 1980

"A Nomogram for the Interpretation of I-131 Field-Sample Measurements without the Need of Numerical Calculations", ENTECH Report P100-R3, January 1981

"A Method of Computing the Gamma Dose Integrals I1 and I2 for the Gaussian Puff Model in Meteorology and Atomic Energy", ENTECH Report P100-R4, May 1981

"DORITA - A Computer Code for the Determination of Radioactivity and Radiation Levels in Various Areas of a Nuclear Power Station and Offsite Following Accidental Releases of Gaseous Fission Products", ENTECH Report P100-R5, October 1981

"SKIRON-II - The Finite-Cloud Gaussian Puff Model, The Valley Model, and Other Revisions", ENTECH Report P100-R6, December 1981

"SKIRON-II - A Computer Code for the Determination of Atmospheric Dispersion Factors for Potential Accident Consequence Assessments at Nuclear Power Plants - A Collection of Relevant Reports", ENTECH Report P100-R7, December 1981

"RADFLEX - A Two-Dimensional Shielding Code for the Determination of Skyshine Radiation from Point-Isotropic Gamma Sources", ENTECH Report P100-R8, January 1982

PROFESSIONAL QUALIFICATIONS

LOUIS P. POCALUJKA

Manager, Monitoring Projects,
Systems Engineering Group

TRC ENVIRONMENTAL CONSULTANTS, INC.

My name is Louis Pocalujka and my business address is TRC Environmental Consultants, Inc., 800 Connecticut Boulevard, East Hartford, Connecticut 06108. I am presently Manager, Monitoring Projects in the Systems Engineering Group, within the Engineering Division of TRC Environmental Consultants, Inc. (TRC). In this capacity, I manage the design, implementation and operation of meteorological and air quality programs. I interface with other groups within TRC, such as Computer Systems, Dispersion Modeling, Quality Assurance, and Permits and Siting in multi-disciplinary projects.

I received my Bachelor of Science degree in Meteorology and Oceanography in 1969 and my Master of Science degree in Meteorology in 1971 from the University of Michigan.

Prior to joining TRC, I worked in the Environmental Division at Sargent & Lundy as a meteorologist. In 1974 I was appointed Supervisor of the Meteorological/Air Quality Section, which grew to a staff of eight meteorologists and air chemists.

My project duties included meteorological input to safety analysis reports, environmental reports and site selection studies for nuclear and fossil fuel power stations. I have worked with design engineers and environmental staff of various disciplines, providing design basis meteorology, dispersion analyses and specifying wind tunnel studies for determining optimum stack and vent heights for minimizing atmospheric impact. I determined requirements for meteorological and air quality monitoring program specifications, made recommendations for purchase and monitored vendor performance. I worked with clients and regulatory agencies in relation to power plant licensing and/or operation. I have been an expert witness in various types of proceedings, including environmental hearings, safety hearings, ACRS hearings, variance petitions and civil suits.

While at the University of Michigan I worked as an Assistant Research Meteorologist and as a Teaching Fellow. I participated in the operation of a meteorological monitoring program for a lakeshore nuclear power plant; was involved in a meteorological and oceanographic field program on Lake Michigan; taught an undergraduate survey course in meteorology and instituted and conducted a special lecture program for elementary and junior high school students.

My non-project responsibilities at TRC include participation in TRC's work group on PSD requirements, participation in TRC's work groups on the NRC's post-TMI licensing and emergency preparedness requirements as they affect meteorological monitoring and modeling, and marketing and sales support. A sampling of my recent project experience includes:

a) Project Manager for TRC's operation of Detroit Edison's Air Quality Monitoring Network. The network is comprised of 20 stations monitoring 96 parameters spread over the utility's service area. The project includes the design and installation of a new microcomputer based, real-time digital system as well as operations and data reduction. The program is required to conform with EPA guidelines for PSD monitoring as well as NRC's Regulatory Guide 1.23 and 10 CFR 50, Appendix B for nuclear licensing purposes.

b) Project Manager working with TRC's Manager of Quality Assurance to provide Virginia Electric Power with a QA/QC critique and evaluation of their Air Quality Division's program, including organization, design, field operations, hardware support, QA/QC practices and data processing.

c) Project Manager for TRC's effort in support of Sandia Laboratories' work to study, design and build a deep salt mine repository for radioactive waste material. TRC's initial contract was to incorporate meteorolgical data collected by Sandia into a report suitable for licensing purposes. Follow-on work included the development of a refined data reduction process for Sandia, quality assurance training, consulting in the development of a quality assurance program for the meteorological and air quality programs at the site and external quality assurance audits of those programs.

d) Project Manager for TRC's licensing work in support of the Illinois Power Company's Clinton Station. This work encompassed meteorological input into the PSAR and FSAR, including accident and long-term modeling. The long-term effort for the FSAR utilized the NRC

MESODIFF Model, recommended for Regulatory Guide 1.111 applications.

e) Project Manager for TRC's licensing efforts for Ohio Edison's proposed Erie Station through their A/E, Commonwealth Associates. TRC provided PSAR input and several revisions to that document. The revisions included long-term X/Q modeling using the NRC's XOQDOQ Model which was developed to respond to Appendix I and Revision 0 of the Regulatory Guide 1.111. Other efforts for this work included control room habitability studies for chemical tank-car accidents and alternate site investigations.

I am affiliated with the ASTM-22 Committee, the American Meteorological Society and the Air Pollution Control Association.

PROFESSIONAL QUALIFICATIONS

JOHN F. SCHMITT

Radiochemistry Engineer

LONG ISLAND LIGHTING COMPANY

My name is John F. Schmitt. I am the Radiochemistry Engineer of the Shoreham Nuclear Power Station, a position I have held since January 1975. As such, I am responsible for developing and implementing the chemistry, radiochemistry and effluent monitoring program for Shoreham. This includes, among other things, directing all work related to conducting the chemical and radiochemical analyses and treatments of plant process systems; detecting and controlling environmental releases; implementing the ALARA policy for these releases; and preparing records and reports of chemical surveys.

I graduated from Manhattan College in 1966 with a Bachelor of Science degree in chemistry and received a Master of Science degree in Environmental Health Science, specializing in Radiological Health (Health Physics), from the University of Michigan in 1974 and became a Certified Health Physicist in 1982. I completed the General Electric Boiling Water Reactor Chemistry Course in November 1975. I have also completed many industry seminars and training programs, including:

a. Radiation Protection - LILCO Evening Institute

b. Radiation Protection Workshops - General Electric Company

c. BWR Chemistry Training - General Electric Company

d. Health Physics Review - Rockwell International

e. Accelerated Health Physics Instruction - NUS

f. Accelerated Nuclear Plant Chemistry Instruction - NUS

g. Health Physics Review - Brookhaven National Labs

h. Environmental Radiation Surveillance - Harvard School of Public Health

i. Radioactive Waste Management for Nuclear Power Reactors - ASME/University of Virginia

j. Post Accident Sampling Workshops - Sentry Equipment, EPRI

k. Control of Plant Radiation Fields - EPRI, General Electric Company

l. Atomic Absorption/Atomic Emission Spectrometry - Instrumentation Labs

m. Gamma Spectrometer Operation - Canberra Industries

I started work for the Long Island Lighting Company in 1966 as an Assistant Engineer at the Far Rockaway Power Station. I took a military leave of absence from 1967-1972 to serve as an officer in the U.S. Air Force. Returning to LILCO in 1972, I was an Associate Engineer at the Glenwood Power Station. From 1973 until assuming my present position in 1975, I was assigned to the staff of the Shoreham Nuclear Power Station as an Associate Engineer and Plant Engineer. During this time, I studied health physics at the University of

Michigan and received training at the AEC's Savannah River Plant and Commonwealth Edison's Dresden Nuclear Power Station.

I am a member of the Health Physics Society, New York Chapter of the Health Physics Society, Power Reactor Health Physicists, and the Long Island Chapter of the American Nuclear Society.

Submitted: NJ DiMascio

Reviewed/OQA Engr.:

Approved/Plant Mgr.: J. Rivello

MC-1

Attachment 14 - 7

SP Number 69.022.01
Revision: 0
Date Eff.: 7/09/82
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DETERMINATION OF OFFSITE DOSES

1.0 PURPOSE

The purpose of this procedure is describe the method to determine offsite doses.

2.0 RESPONSIBILITY

The Radiation Protection Manager/Radiological Control Manager shall be responsible for the implementation of this procedure.

3.0 DISCUSSION

3.1 This procedure is used to determine offsite doses based upon short term, abnormal release conditions. The dose calculations are based upon finite cloud analyses.

3.2 There are two methods described in this procedure. One makes use of the computerized radiation monitoring system (RMS), while the other is a manual method to be used in cases of RMS unavailability.

3.3 The computerized RMS method described in the procedure assumes that the software is running in the ACCIDENT mode. This mode is selected either manually or automatically by the RMS. It is important to note that initial dose assessment, prior to grab sample analyses, is based upon an assumed inventory mixture of nuclides (i.e. LOCA, fuel handling).

3.4 The manual method described in this procedure employs the use of nomograms for dose assessment. There are eight (8) nomograms from which to select. Each nomogram is based upon assumed LOCA nuclide release mixtures. When using this method, it is important to understand the bases and assumptions described on each nomogram.

3.4.1 Only whole body dose calculations are provided for the normal station ventilation exhaust monitor. These doses assume 100% noble gas LOCA mixtures.

3.4.2 Both whole body and thyroid dose calculations are provided for the reactor building standby ventilation system monitor. These doses assume 100% noble gas LOCA mixtures for the whole body, and 25% halogen LOCA mixtures with 99% filtration for thyroid doses.

3.5 This procedure details the method to obtain dose projection for one point from beginning to end. The Radiation Protection Manager/Radiological Control Manager can have several different people doing this calculation for different distances simultaneously. If this is the case, the worksheet (Appendix 12.1) is filled out until the atmospheric dispersion factor (item 13) is obtained. Once this is done the highest dose can be obtained by using the nomograms for situations where time limits are constrained. The RPM/RCM will use the best method for completing this procedure depending on staff availability.

3.6 Topics covered in this procedure:

Appendix 12.4 Plume Centerline Concentration (Xu/Q)
Appendix 12.5 Gaussian Puff Gamma (Xu/Q)
Appendix 12.6 Nomograms

4.0 PRECAUTIONS

N/A

5.0 PREREQUISITES

N/A

6.0 LIMITATIONS AND ACTIONS

6.1 Personnel using this procedure should be aware of the bases for the assumed nuclide mixtures used in the dose calculations.

7.0 MATERIALS AND EQUIPMENT

7.1 Radiation Monitoring System

8.0 PROCEDURE

8.1 Determination of offsite doses using the computerized radiation monitoring system. (RMS)

(LATER)

8.2 Determination of offsite doses using the nomograms.

8.2.1 Dose Assessment Staff Members or In-plant Radiation Monitoring Technician, obtain a copy of the Radioactive Effluent Monitor Nomogram Worksheet (Appendix 12.1) and fill out the worksheet using the following instructions:

8.2.1.1 Record the current date (item 1) and time (item 2)

8.2.1.2 Obtain wind speed (item 3) and wind direction (item 4) for both 150 ft. and 33 ft. tower levels from either the Control Room or local tower readouts. Convert wind speed to appropriate units. Determine affected downwind sector (item 4) by referring to the following table:

Indicated Wind Direction	Affected Downwind Sector
0 to 11.25	S
11.25 to 33.75	SSW
33.75 to 56.25	SW
56.25 to 78.75	WSW
78.75 to 101.25	W
101.25 to 123.75	WNW
123.75 to 146.25	NW
146.25 to 168.75	NNW
168.75 to 191.25	N
191.25 to 213.75	NNE
213.75 to 236.25	NE
236.25 to 258.75	ENE

Indicated Wind Direction	Affected Downwind Sector
258.75 to 281.25	E
281.25 to 303.75	ESE
303.75 to 326.25	SE
326.25 to 348.75	SSE
348.75 to 371.25	S
371.25 to 393.75	SSW
393.75 to 416.25	SW
416.25 to 438.75	WSW
438.75 to 461.25	W
461.25 to 483.75	WNW
483.75 to 506.25	NW
506.25 to 528.75	NNW
528.75 to 540.00	N

8.2.1.3 Determine atmospheric stability class (item 5a, b, or c) using one of the following methods:

.1 Obtain the 33-150 ft. temperature difference (item 5a) from the Control Room or local tower readout. Choose the correct stability class from the following table:

Delta-T (°F) 33-150 ft	Stability Class	Atmospheric Condition
Less than -1.22	A	Extremely Unstable
-1.22 to -1.09	B	Moderately Unstable
-1.09 to -0.96	C	Slightly Unstable
-0.96 to 0.32	D	Neutral
0.32 to 0.96	E	Slightly Stable
0.96 to 2.57	F	Moderately Stable
Greater than 2.57	G	Extremely Stable

NOTE: For borderline cases, choose the most stable class (e.g., if delta-T = 0.32, choose stability Class E).

.2 If the temperature difference (item 5a) is not available, record the standard deviation of wind direction fluctuation (sigma theta - item 5b) from either the 33-ft. level of the primary tower or the backup tower, and choose the correct stability class from the following list:

sigma theta (degrees) 33-ft. Level	Stability Class	Atmospheric Condition
Greater than 22.5	A	Extremely Unstable
17.5 to 22.5	B	Moderately Unstable
12.5 to 17.5	C	Slightly Unstable
7.5 to 12.5	D	Neutral
3.8 to 7.5	E	Slightly Stable
2.1 to 3.8	F	Moderately Stable
Less than 2.1	G	Extremely Stable

NOTE: For borderline cases, choose the most stable class (e.g., if sigma theta = 7.5, choose stability Class E).

.3 If no delta-T or sigma theta data is available, choose the stability class using the wind speed from item 3 and the following table:

33-ft Wind Speed (mph)	Day			Night	
	Incoming Solar Radiation			Degree of Cloudiness	
	Strong	Moderate	Slight	>50%	<50%
< 4	A	A-B	B		
4-7	A-B	B	C	E	F
7-11	B	B-C	C	D	E
11-14	C	C-D	D	D	D
>14	C	D	D	D	D

The degree of cloudiness is defined as that fraction of the sky above the local apparent horizon that is covered by clouds. The neutral Class D, should be assumed for heavy overcast conditions during day or night.

NOTE: For borderline windspeed, choose the most stable class (e.g. if windspeed = 11 mph, choose stability Class C for daytime with strong incoming solar radiation).

8.2.1.4 Determine the type of release (ground-level or elevated) by contacting the Control Room and obtaining the station vent average flow rate (item 6a). Calculate the exit velocity (item 6b) and the velocity ratio (item 6c). Circle the release type (item 6d).

8.2.1.5 Radiation Protection Manager, Radiological Control Manager, or In-plant Radiation Monitoring Technician, determine the distance to downwind receptor (item 7).

NOTE: Use judgement when picking valves at which to perform dose projection. Take into account factors such as windspeed, stability class, affected areas, and population density. Dose projection can only be done for distances given in Appendix 12.3. If dose assessment staff members are available, several calculations can be performed simultaneously at different distances. If this is the case the Radioactive Effluent Monitor Nomogram Worksheet (Appendix 12.1) can be completed for these different distances up to item 13 (atmospheric dispersion factor) and recorded on the Tabulated Dose and Protective Action Worksheet (Appendix 12.2) before using the nomograms and completing the worksheets.

8.2.1.6 Determine receptor elevation above mean sea level (MSL) by using Appendix 12.3 along with stability class (item 5) and distance to downwind receptor (item 7).

NOTE: THIS STEP FOR ELEVATED RELEASES ONLY.

8.2.1.7 Determine plume rise (item 9) for the appropriate stability class (item 5), and record the lowest valve using the guidance on the worksheet.

NOTE: THIS STEP FOR ELEVATED RELEASES ONLY

8.2.1.8 Calculate the effective plume height above receptor (item 10) and then choose the tabulated plume height closest to this value.

NOTE: THIS STEP FOR ELEVATED RELEASES ONLY

8.2.1.9 Contact the Control Room and determine the release point (item 11). Determine the type of exposure (item 12) by circling the system affected.

8.2.1.10 Determine the atmospheric dispersion factor for type of exposure (whole body gamma and/or thyroid) as follows:

.1 Select the gaussian puff gamma Xu/Q tables (Appendix 12.5) for whole body exposure or plume centerline concentration Xu/Q tables (Appendix 12.4) for thyroid exposure.

.2 From type of release (item 5) and/or tabulated plume height (item 10 - for elevated releases), choose the proper table for whole body and/or thyroid exposure.

.3 Find the proper Xu/Q value using the stability class (item 5) and distance to downwind receptor (item 7). Record the Xu/Q value (item 13) on the worksheet.

8.2.1.11 Contact the Control Room and determine the radiation monitor reading (item 14) in cpm. If the radiation monitor reading is offscale or inoperable obtain Xe-133 and I-131 dose equivalents from results of a grab sample.

NOTE: Inform RPM or RCM that a sample is needed if not already taken.

8.2.1.12 Based upon release point (item 11), type of exposure (item 12) and radiation monitor reading or dose equivalents (item 14) determine the proper nomogram(s) to use. Record the number(s) on the worksheet (item 15) and obtain a copy of the nomogram (Appendix 12.6).

Nomogram No.	Description
1	Station vent routine effluent monitor • noble gas release • wholebody gamma dose
2	Station vent high-range monitor • noble gas release • wholebody gamma dose
3	RBSVS low-range monitor • noble gas release • wholebody gamma dose
4	RBSVS low-range monitor • potential halogen release rate • potential thyroid dose rate
5	RBSVS intermediate-range monitor • noble gas release • wholebody gamma dose
6	RBSVS intermediate-range monitor • potential halogen release rate • potential thyroid dose
7	RBSVS high-range monitor • noble gas release • wholebody gamma dose
8	RBSVS high-range monitor • potential halogen release rate • potential thyroid dose rate

8.2.1.13 Contact the Control Room to determine the airflow at the duct sampled or monitored (item 16) and time of reactor scram (item 17). Determine time since reactor scram.

NOTE: If the reactor is not yet shutdown, the time since reactor scram is zero.

8.2.1.14 Use the selected nomogram and the following information to compute the radioactivity release rate and the dose rate (item 18) at the receptor of interest:

- Monitor reading or grab sample concentration (from Step 14)
- Vent flow (from Step 16)
- Time since reactor scram (from Step 17)
- Prevailing wind speed (from Step 3 in mph; use the 33-ft data for a ground-level release and the 150-ft data for an elevated release as determined in Step 6)
- The Xu/Q value (from Step 13)

8.2.1.15 To Determine Dose Rate

.1 Locate the monitor reading on the left hand axis. If monitor reading is unavailable, use grab sample dose equivalent and continue with Step 8.2.14.4.

.2 Move horizontally to the right until the slanted line corresponding to the flow rate is intercepted.

.3 Move vertically up until slanted line corresponding to time after reactor shutdown is intercepted.

.4 Move horizontally to the right until slanted line corresponding to wind speed is intercepted.

NOTE: For elevated releases, use elevated windspeed; for ground releases, use ground windspeed.

.5 Move vertically down until the slanted line corresponding to the atmospheric dispersion factor is intercepted.

.6 Move horizontally to the right and read off the dose rate.

8.2.1.16 To Determine Release Rate

.1 Locate the monitor reading on the left hand axis.

.2 Move horizontally to the right until the slanted line corresponding to the flow rate is intercepted.

.3 Move vertically down until slanted line corresponding to time after reactor shutdown is intercepted.

.4 Move horizontally to the left and read off the release rate.

8.2.1.17 Contact the Control Room and determine release duration (item 19).

8.2.1.18 Complete item 20 to determine whole body and thyroid dose for the point of interest. Record them on Appendix 12.1.

9.0 ACCEPTANCE CRITERIA

N/A

10.0 FINAL CONDITIONS

Projected whole body and/or thyroid doses for points of interest have been calculated.

11.0 REFERENCES

Shoreham Nuclear Power Station Emergency Plan

12.0 APPENDICES

12.1 Radioactive Effluent Monitor Nomogram Worksheet, SPF69.022.01-1

12.2 Tabulated Dose and Protective Action Worksheet, SPF69.022.01-2

12.3 Terrain Heights

12.4 Plume Centerline Concentration Xu/Q

12.5 Gaussian Puff Gamma Xu/Q

12.6 Nomograms

RADIOACTIVE EFFLUENT MONITOR NOMOGRAM WORKSHEET

Your Name:____________________

1. Date:____________________ 2. Time:__________________

3. Wind speed: u(33-ft level)____mph; X 0.447 = __________m/sec
u(150-ft level)____mph; X 0.447 = __________m/sec

4. Wind direction: 33-ft level__________degrees; __________sector
150-ft level__________degrees; __________sector

(See page 3 of procedure for affected downwind sector)

5. Atmospheric Stability (Pick one - use a, b, or c in that order. See Step 8.2.1.3 for instructions).

a. Delta Temperature: (33-150 ft)__________deg. F; stability____________
b. Sigma Theta (33 ft) __________; stability_______________

c. Wind Speed (33 ft) __________mph;

Time of Day (Choose one and circle appropriate condition in parenthesis)
Day - Incoming Solar Radiation (Strong, Moderate, Slight)
Night - Degree of Cloudiness (>50%, <50%)

Stability_________________

6. Release Type

a. Station vent flow: F______________cfm

b. Exit velocity : W_o = F(cfm) X 8.47 X 10-5 = ________m/sec

c. Velocity ratio : R_v = W_o(m/sec) / u(150-ft; m/sec) = __________

NOTE: If R_v is less than 5, the release is to be assumed to be at ground level; if R_v is greater than or equal to 5 the release is elevated.

d. Release type (circle one): ground release elevated release

7. Distance to downwind receptor: X = ______________miles

NOTE: FOR GROUND RELEASE (item 6d) PROCEED DIRECTLY TO STEP 11

8. Receptor elevation: h_t = _______m above MSL (ELEVATED RELEASE ONLY) from Appendix 12.3; use stability class (item 5) and distance to downwind receptor (item 7).

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9. Plume rise: (FOR ELEVATED RELEASES ONLY)

Compute hpr(1) and hpr(2) for all stabilities:

hpr(1) = $32.4\ (Rv^2\ X)^{1/3}$ = ____________m

hpr(2) = 7.98 Rv = ____________m

Compute hpr(3) and hpr(4) for stability classes E, F, and G only:

hpr(3) = $30\ Wo^{1/2}$ = ____________m (stability E)

= $24\ Wo^{1/2}$ = ____________m (stability F)

= $21\ Wo^{1/2}$ = ____________m (stability G)

hpr(4) = $6.4\ (RvWo)^{1/3}$ = ________m (stability E)

= $5.5\ (RvWo)^{1/3}$ = ________m (stability F)

= $4.9\ (RvWo)^{1/3}$ = ________m (stability G)

Choose the final plume rise (hpr) as follows:

Stabilities A, B, C, and D

h_{pr} = lesser of h_{pr} (1) and hpr (2) = _________m

Stabilities E, F, and G

h_{pr} = lesser of h_{pr} (1) through h_{pr} (4) = _____m

10. Effective plume height above receptor (FOR ELEVATED RELEASES ONLY). Use hpr (item 9) and h_t (item 8)

he = 75.9 + hpr - ht

= 75.9 + _________ - ________ = _________m

Tabulated plume height (H) closest to he is:

H (choose 35, 70, 105 or 140) = ________m

11. Release point (circle one): Station Vent; RBSVS

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12. Type of exposure (circle release point): whole body (station vent or RBSVS)
thyroid (RBSVS only)

13. Atmospheric dispersion factor

Type of exposure (item 12):

Whole Body - Use gaussian puff gamma Xu/Q tables (Appendix 12.3)
Thyroid - Use plume centerline concentration Xu/Q tables (Appendix 12.4)

Type of Release:

(Ground or elevated. If elevated release use tabulated plume height from item 10. Use proper table for thyroid and/or whole body exposure).

Choose one: ground level release
elevated release (H = 35 m)
elevated release (H = 70 m)
elevated release (H = 105 m)
elevated release (H = 140 m)

Stability and distance (item 5 and 7)

Find the proper Xu/Q value for whole body and/or thyroid exposure using stability class (item 5) and distance to downwind receptor (item 7).

Xu/Q (whole body) = ______________ ($1/m^2$)
Xu/Q (thyroid) = ______________ ($1/m^2$)

NOTE: Record these values and distance (item 7) or Appendix 12.2

14. Radiation monitor reading: ________cpm; Xe-133 Dose Eq.______________uCi/cc
I-131 Dose Eq.______________uCi/cc

15. Number of nomogram selected: ____________ (Whole Body)

____________ (Thyroid)

16. Air flow at the duct sampled or monitored: __________________cfm

17. Time of reactor scram:__________; Time since reactor scram___________hours
(24 hr clock)

18. a. Radioactivity release rate:________uCi/sec; noble gas

b. Offsite dose rate:________________mr/hr; whole body gamma

c. Radioactivity release rate:________uCi/sec; radioiodine

d. Offsite dose rate:________________mr/hr; thyroid

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19. Release duration: ______________ hrs.

20a. Whole Body Dose = Item 18b x item 19

= ______ x ______ / 1000 = ________ rem

b. Thyroid Dose = Item 18d x item 19

= ______ x ______ / 1000 = ________ rem

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TABULATED DOSE AND PROTECTIVE ACTION WORKSHEET

DISTANCE (MILES)	DISPERSION COEFFICIENT		PROJECTED DOSE		EVACUATION DOSE		SHELTER DOSE		RECOMMENDATION	
	THYROID (XU/Q) $(10^{-6} m^{-2})$	WHOLE BODY (XU/Q) $(10^{-6} m^{-2})$	THYROID (REM)	WHOLE BODY (REM)	THYROID (REM)	WHOLE BODY (REM)	THYROID, (REM)	WHOLE BODY (REM)	THYROID	WHOLE BODY
SITE BOUNDARY										

TERRAIN HEIGHTS (METERS ABOVE MSL)

MILES	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
.19	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
.25	0	0	0	3	4	4	13	17	21	22	17	15	15	4	0	0
.50	0	0	0	3	4	4	18	30	31	32	17	26	27	13	0	0
.75	0	0	0	9	4	18	26	52	58	58	31	33	31	0	0	0
1.0	0	0	0	25	27	18	50	40	37	41	46	33	31	0	0	0
1.5	0	0	0	3	48	49	37	31	31	33	40	46	37	0	0	0
2.0	0	0	0	0	67	35	33	27	27	23	40	52	30	0	0	0
2.5	0	0	0	0	87	30	31	24	24	37	37	45	30	0	0	0
3.0	0	0	0	0	24	30	23	24	25	31	34	48	39	0	0	0
3.5	0	0	0	0	34	30	27	24	24	30	33	40	33	0	0	0
4.0	0	0	0	0	47	30	22	19	24	27	32	35	33	0	0	0
4.5	0	0	0	0	33	27	15	18	21	27	28	33	30	0	0	0
5.0	0	0	0	0	39	27	13	18	21	30	28	40	35	0	0	0
7.5	0	0	0	0	30	21	31	15	25	38	27	40	50	0	0	0
10.	0	0	0	0	21	12	76	33	27	40	44	45	37	0	0	0

SHOREHAM STATION - PLUME-CENTERLINE CONCENTRATION (X*U/Q) (1/M2)

GROUND-LEVEL RELEASE - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.18	73.824	142.587	218.895	451.874	733.325	1528.773	3529.488
.25	40.552	83.888	155.855	307.503	517.204	1038.081	2177.300
.50	8.336	25.814	58.855	134.300	203.135	428.881	848.132
.75	2.668	10.212	28.688	80.639	132.840	244.168	488.847
1.0	2.089	4.832	18.422	55.140	84.347	165.540	336.834
1.5	1.488	2.004	8.447	31.746	55.471	106.474	195.837
2.0	1.147	1.561	5.844	20.816	38.311	74.644	137.574
2.5	.845	1.295	4.019	14.781	28.672	57.284	106.706
3.0	.816	1.089	2.858	11.342	22.585	47.484	89.414
3.5	.720	.944	2.283	8.060	18.490	40.239	76.541
4.0	.644	.838	1.825	7.503	15.572	34.709	66.853
4.5	.585	.758	1.495	6.342	13.398	30.134	58.585
5.0	.536	.693	1.258	5.469	11.722	28.807	52.261
7.5	.368	.487	.713	3.206	7.151	17.112	34.340
10.0	.288	.390	.524	2.184	5.020	12.809	25.580
15.0	.214	.274	.360	1.204	3.036	8.009	16.872
20.0	.166	.215	.281	.811	2.185	5.881	12.691
25.0	.138	.178	.245	.603	1.708	4.592	10.208
30.0	.120	.155	.213	.478	1.415	3.783	8.580
35.0	.106	.136	.188	.393	1.203	3.225	7.408
40.0	.096	.122	.168	.333	1.044	2.800	6.526
45.0	.087	.110	.148	.281	.927	2.482	5.853
50.0	.080	.100	.135	.258	.829	2.222	5.302

SHOREHAM STATION - PLUME-CENTERLINE CONCENTRATION (X*U/Q) (1/M2)

ELEVATED RELEASE (H = 35 M) - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.10	68.928	108.063	113.557	28.242	1.460	.000	.000
.25	39.738	81.890	109.985	58.158	12.023	.006	.000
.50	6.358	25.347	52.257	85.824	75.274	8.315	.021
.75	2.678	10.179	28.570	83.828	78.718	36.060	1.899
1.0	2.084	4.932	17.988	47.501	68.012	53.482	8.535
1.5	1.480	2.007	9.336	28.294	46.335	57.480	25.584
2.0	1.148	1.563	5.803	19.517	33.868	49.653	31.486
2.5	.945	1.298	4.000	14.188	26.067	42.113	34.222
3.0	.817	1.089	2.848	10.984	20.847	36.862	35.828
3.5	.720	.945	2.277	8.843	17.257	32.380	35.481
4.0	.644	.838	1.821	7.337	14.657	28.644	34.054
4.5	.585	.758	1.492	6.220	12.700	25.335	31.933
5.0	.538	.693	1.256	5.375	11.174	22.693	29.973
7.5	.368	.497	.713	3.169	6.917	15.173	23.013
10.0	.288	.380	.524	2.148	4.808	11.407	18.378
15.0	.214	.274	.360	1.187	2.876	7.488	12.814
20.0	.166	.215	.291	.808	2.149	5.485	10.097
25.0	.138	.179	.245	.601	1.685	4.338	8.305
30.0	.120	.155	.213	.476	1.397	3.601	7.063
35.0	.106	.138	.188	.392	1.189	3.073	6.158
40.0	.096	.122	.168	.332	1.033	2.878	5.470
45.0	.087	.110	.149	.291	.917	2.380	4.841
50.0	.080	.100	.135	.257	.821	2.137	4.503

SHOREHAM STATION - PLUME-CENTERLINE CONCENTRATION (X*U/Q) (1/M2)

ELEVATED RELEASE (H = 70 M) - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.18	36.107	17.438	3.011	.000	.000	0.000	0.000
.25	28.850	28.170	12.598	.048	.000	.000	0.000
.50	6.220	20.704	27.534	7.216	.825	.000	.000
.75	2.678	8.557	20.869	15.801	5.278	.017	.000
1.0	2.094	4.811	14.825	18.538	10.678	.306	.000
1.5	1.490	2.005	8.453	17.158	15.615	2.688	.008
2.0	1.148	1.563	5.464	13.491	15.683	5.811	.065
2.5	.845	1.286	3.838	10.754	14.247	7.868	.218
3.0	.817	1.089	2.859	8.824	12.511	8.982	.548
3.5	.720	.945	2.223	7.383	11.092	8.448	.857
4.0	.644	.838	1.787	6.292	8.929	9.519	1.366
4.5	.585	.758	1.470	5.442	8.893	9.286	1.679
5.0	.536	.693	1.240	4.774	8.187	8.878	1.956
7.5	.368	.497	.711	2.928	5.563	7.417	2.855
10.0	.288	.390	.524	2.025	4.105	6.240	3.237
15.0	.214	.274	.360	1.155	2.611	4.668	3.058
20.0	.166	.215	.291	.786	1.830	3.687	2.878
25.0	.138	.179	.245	.588	1.535	3.046	2.639
30.0	.120	.155	.213	.468	1.283	2.600	2.382
35.0	.106	.136	.188	.386	1.100	2.272	2.181
40.0	.096	.122	.168	.328	.961	2.021	2.019
45.0	.087	.110	.149	.268	.857	1.829	1.891
50.0	.080	.100	.135	.255	.770	1.668	1.778

SHOREHAM STATION - PLUME-CENTERLINE CONCENTRATION (X*U/Q) (1/M2)

ELEVATED RELEASE (H = 105 M) - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.18	12.281	.834	.007	.000	.000	0.000	0.000
.25	18.698	5.221	.340	.000	.000	0.000	0.000
.50	5.998	14.777	9.484	.118	.000	.000	0.000
.75	2.678	8.602	12.364	1.538	.057	.000	.000
1.0	2.094	4.817	10.730	3.864	.488	.000	.000
1.5	1.490	2.001	7.162	7.036	2.548	.016	.000
2.0	1.148	1.563	4.943	7.291	4.347	.163	.000
2.5	.945	1.298	3.583	6.768	5.205	.481	.000
3.0	.817	1.089	2.717	6.125	5.342	.854	.001
3.5	.720	.945	2.137	5.464	5.310	1.213	.002
4.0	.644	.838	1.731	4.871	5.188	1.518	.006
4.5	.585	.758	1.432	4.355	5.059	1.743	.012
5.0	.536	.693	1.215	3.919	4.878	1.815	.021
7.5	.368	.497	.707	2.566	3.869	2.250	.097
10.0	.288	.390	.523	1.837	3.070	2.283	.179
15.0	.214	.274	.360	1.087	2.100	2.124	.277
20.0	.166	.215	.291	.752	1.814	1.898	.355
25.0	.138	.179	.245	.567	1.313	1.690	.390
30.0	.120	.155	.213	.454	1.115	1.511	.389
35.0	.106	.138	.188	.377	.967	1.374	.387
40.0	.096	.122	.168	.321	.852	1.264	.383
45.0	.087	.110	.148	.282	.765	1.179	.381
50.0	.080	.100	.135	.251	.691	1.104	.378

SHOREHAM STATION - PLUME-CENTERLINE CONCENTRATION (X*U/Q) (1/M2)

ELEVATED RELEASE (H = 140 M) - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.19	2.719	.012	.000	.000	0.000	0.000	0.000
.25	8.666	.470	.002	.000	.000	0.000	0.000
.50	5.836	8.216	2.122	.000	.000	.000	0.000
.75	2.678	7.424	5.842	.058	.000	.000	0.000
1.0	2.094	4.358	6.824	.430	.006	.000	.000
1.5	1.490	1.995	5.679	2.020	.201	.000	.000
2.0	1.148	1.563	4.295	3.080	.721	.001	.000
2.5	.945	1.296	3.254	3.539	1.271	.010	.000
3.0	.817	1.088	2.530	3.674	1.623	.032	.000
3.5	.720	.945	2.021	3.586	1.883	.069	.000
4.0	.644	.838	1.656	3.404	2.091	.118	.000
4.5	.585	.758	1.382	3.188	2.261	.168	.000
5.0	.536	.693	1.181	2.972	2.360	.220	.000
7.5	.368	.497	.702	2.134	2.327	.424	.001
10.0	.288	.390	.522	1.604	2.043	.559	.003
15.0	.214	.274	.360	1.000	1.548	.705	.010
20.0	.168	.215	.291	.706	1.256	.747	.018
25.0	.138	.178	.245	.540	1.056	.741	.027
30.0	.120	.155	.213	.435	.915	.707	.031
35.0	.106	.136	.188	.363	.806	.678	.034
40.0	.096	.122	.168	.312	.720	.655	.037
45.0	.087	.110	.149	.275	.652	.638	.041
50.0	.080	.100	.135	.246	.594	.618	.043

SHOREHAM STATION - GAUSSIAN PUFF GAMMA (X*U/Q) (1/M2)

GROUND-LEVEL RELEASE - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.10	39.619	60.088	77.110	113.774	144.884	205.887	302.162
.25	28.073	48.380	63.374	82.861	121.875	171.491	242.415
.50	5.648	18.542	33.169	57.865	73.815	110.505	155.705
.75	1.285	6.628	20.653	42.003	57.529	81.865	118.788
1.0	.974	4.483	14.175	32.469	46.510	65.688	87.599
1.5	.697	1.597	8.063	21.733	32.606	50.222	72.387
2.0	.539	.788	5.250	15.523	25.008	38.811	58.816
2.5	.445	.608	3.716	11.829	20.109	33.347	50.281
3.0	.384	.512	2.785	9.448	16.694	29.220	44.929
3.5	.339	.444	2.174	7.787	14.217	25.826	40.582
4.0	.304	.394	1.751	6.577	12.347	23.241	36.890
4.5	.276	.357	1.439	5.655	10.886	20.889	33.869
5.0	.253	.327	1.209	4.941	8.718	18.882	31.273
7.5	.174	.235	.630	3.005	6.301	13.346	23.056
10.0	.136	.184	.400	2.065	4.568	10.342	18.410
15.0	.101	.128	.217	1.188	2.854	7.032	13.182
20.0	.079	.102	.151	.793	2.084	5.264	10.389
25.0	.065	.084	.116	.591	1.644	4.208	8.827
30.0	.057	.073	.101	.489	1.388	3.520	7.409
35.0	.050	.064	.089	.385	1.168	3.022	6.503
40.0	.045	.058	.078	.326	1.016	2.643	5.803
45.0	.041	.052	.071	.283	.904	2.355	5.257
50.0	.038	.047	.064	.249	.810	2.118	4.803

SHOREHAM STATION - GAUSSIAN PUFF GAMMA (X*U/Q) (1/M2)

ELEVATED RELEASE (H = 35 M) - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.19	39.247	58.930	72.641	80.560	77.485	73.502	72.221
.25	25.949	48.080	61.984	78.208	80.137	75.124	72.785
.50	5.664	18.585	33.349	58.622	72.218	80.618	77.128
.75	1.290	8.651	20.805	43.178	58.763	75.802	80.544
1.0	.877	4.505	14.285	33.443	48.144	68.050	78.403
1.5	.699	1.601	8.119	22.308	33.933	53.908	71.608
2.0	.540	.789	5.280	15.910	25.894	43.089	63.938
2.5	.445	.609	3.734	12.098	20.879	36.032	57.228
3.0	.385	.512	2.797	8.639	17.331	31.518	51.451
3.5	.339	.445	2.182	7.831	14.744	27.932	46.651
4.0	.304	.385	1.757	6.688	12.788	25.018	42.635
4.5	.278	.357	1.443	5.743	11.254	22.482	39.173
5.0	.253	.327	1.212	5.014	10.032	20.422	36.256
7.5	.174	.235	.832	3.040	6.471	14.320	26.714
10.0	.138	.184	.400	2.085	4.878	11.060	21.300
15.0	.101	.130	.217	1.178	2.812	7.472	15.242
20.0	.079	.102	.151	.797	2.121	5.584	11.851
25.0	.065	.085	.118	.584	1.671	4.430	9.880
30.0	.057	.073	.101	.471	1.389	3.699	8.474
35.0	.050	.064	.089	.387	1.184	3.167	7.427
40.0	.045	.058	.078	.327	1.030	2.784	6.615
45.0	.041	.052	.071	.284	.916	2.458	5.981
50.0	.038	.047	.064	.250	.820	2.208	5.454

SHOREHAM STATION - GAUSSIAN PUFF GAMMA (X*U/Q) (1/M2)

ELEVATED RELEASE (H = 70 M) - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.18	28.871	33.441	32.128	28.762	27.885	27.372	27.171
.25	21.888	31.315	33.468	30.080	28.482	27.582	27.265
.50	5.481	16.452	26.085	33.428	32.223	29.087	27.838
.75	1.282	8.211	18.128	30.384	33.434	31.300	28.744
1.0	.873	4.391	13.055	28.114	31.873	32.873	29.989
1.5	.697	1.589	7.732	19.208	26.371	32.984	32.354
2.0	.539	.787	5.121	14.374	21.718	30.356	33.385
2.5	.445	.607	3.657	11.223	18.181	27.419	33.347
3.0	.384	.512	2.755	9.090	15.488	25.088	32.599
3.5	.339	.444	2.158	7.563	13.431	22.850	31.476
4.0	.304	.385	1.741	6.429	11.807	21.074	30.192
4.5	.276	.357	1.434	5.554	10.500	19.332	28.842
5.0	.253	.327	1.208	4.871	9.436	17.845	27.528
7.5	.174	.235	.830	2.990	6.229	13.083	22.183
10.0	.136	.184	.400	2.063	4.554	10.332	18.487
15.0	.101	.130	.217	1.170	2.867	7.148	13.836
20.0	.079	.102	.151	.784	2.098	5.387	11.098
25.0	.065	.085	.116	.593	1.657	4.320	9.302
30.0	.057	.073	.101	.470	1.380	3.623	8.053
35.0	.050	.064	.089	.388	1.178	3.113	7.105
40.0	.045	.058	.079	.328	1.025	2.723	6.362
45.0	.041	.052	.071	.284	.812	2.426	5.775
50.0	.038	.047	.064	.250	.817	2.181	5.284

SHOREHAM STATION - GAUSSIAN PUFF GAMMA (X*U/Q) (1/M2)

ELEVATED RELEASE (H = 105 M) - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.10	17.821	15.898	14.108	12.907	12.818	12.432	12.357
.25	16.204	17.623	15.346	13.309	12.818	12.509	12.393
.50	5.177	13.490	17.600	16.043	14.160	13.008	12.601
.75	1.267	7.521	14.463	17.823	16.022	13.734	12.901
1.0	.864	4.188	11.250	17.611	17.430	14.691	13.280
1.5	.683	1.585	7.122	15.042	17.661	16.737	14.235
2.0	.537	.781	4.857	12.180	16.216	17.827	15.262
2.5	.443	.604	3.524	8.909	14.493	17.823	16.249
3.0	.383	.510	2.681	8.240	12.896	17.387	17.048
3.5	.338	.443	2.113	6.980	11.515	16.699	17.574
4.0	.303	.393	1.712	6.010	10.347	15.938	17.849
4.5	.276	.356	1.414	5.243	9.356	15.105	17.920
5.0	.253	.326	1.192	4.632	8.518	14.306	17.836
7.5	.174	.234	.627	2.902	5.836	11.271	16.406
10.0	.136	.184	.398	2.022	4.346	8.226	14.860
15.0	.101	.129	.216	1.157	2.785	6.626	11.785
20.0	.078	.102	.151	.788	2.058	5.084	9.814
25.0	.065	.085	.116	.590	1.631	4.132	8.411
30.0	.057	.073	.101	.468	1.382	3.492	7.380
35.0	.050	.064	.088	.385	1.163	3.017	6.591
40.0	.045	.058	.078	.326	1.016	2.650	5.951
45.0	.041	.052	.071	.283	.905	2.368	5.438
50.0	.038	.047	.064	.249	.812	2.135	5.003

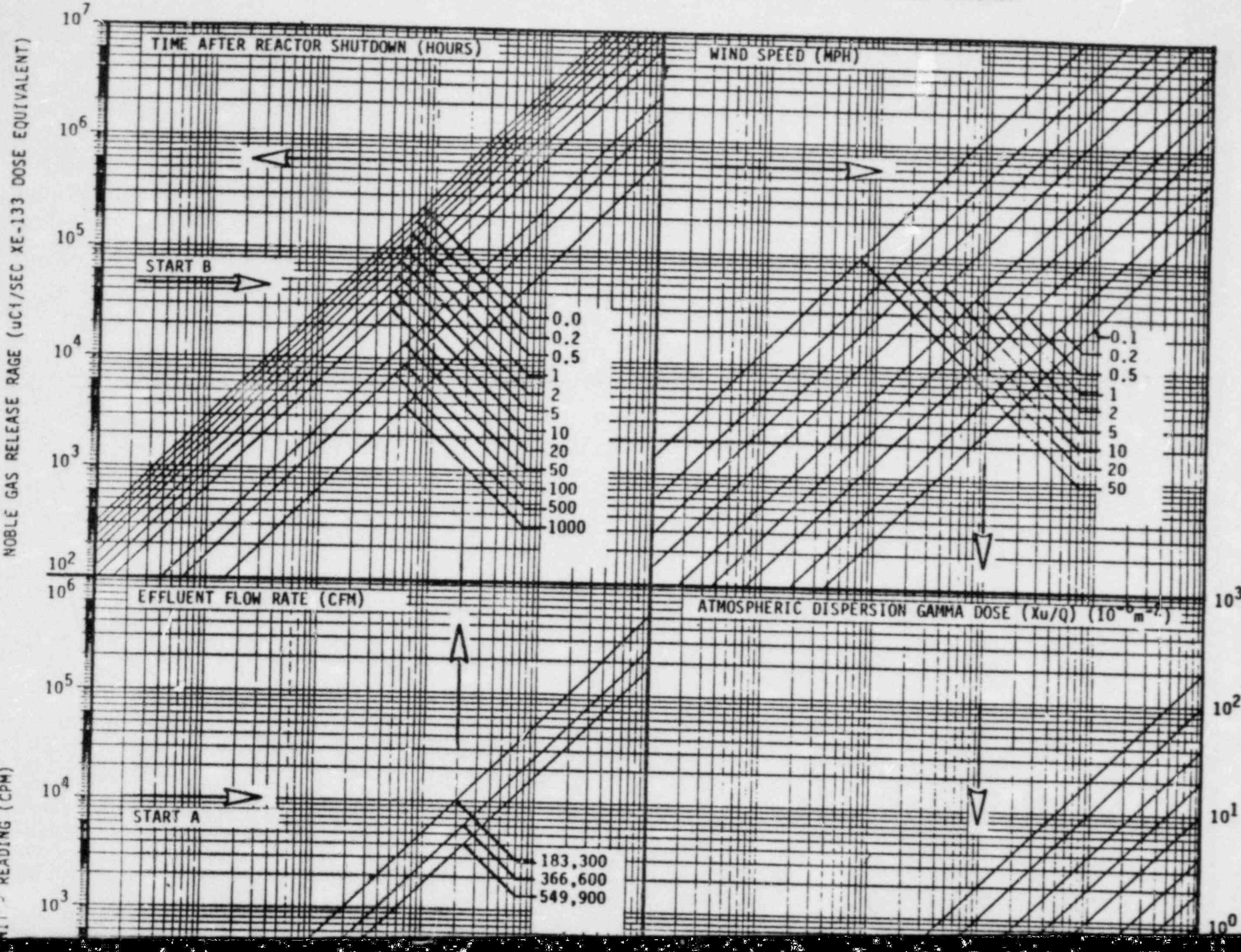
SHOREHAM STATION - GAUSSIAN PUFF GAMMA (X*U/Q) (1/M2)

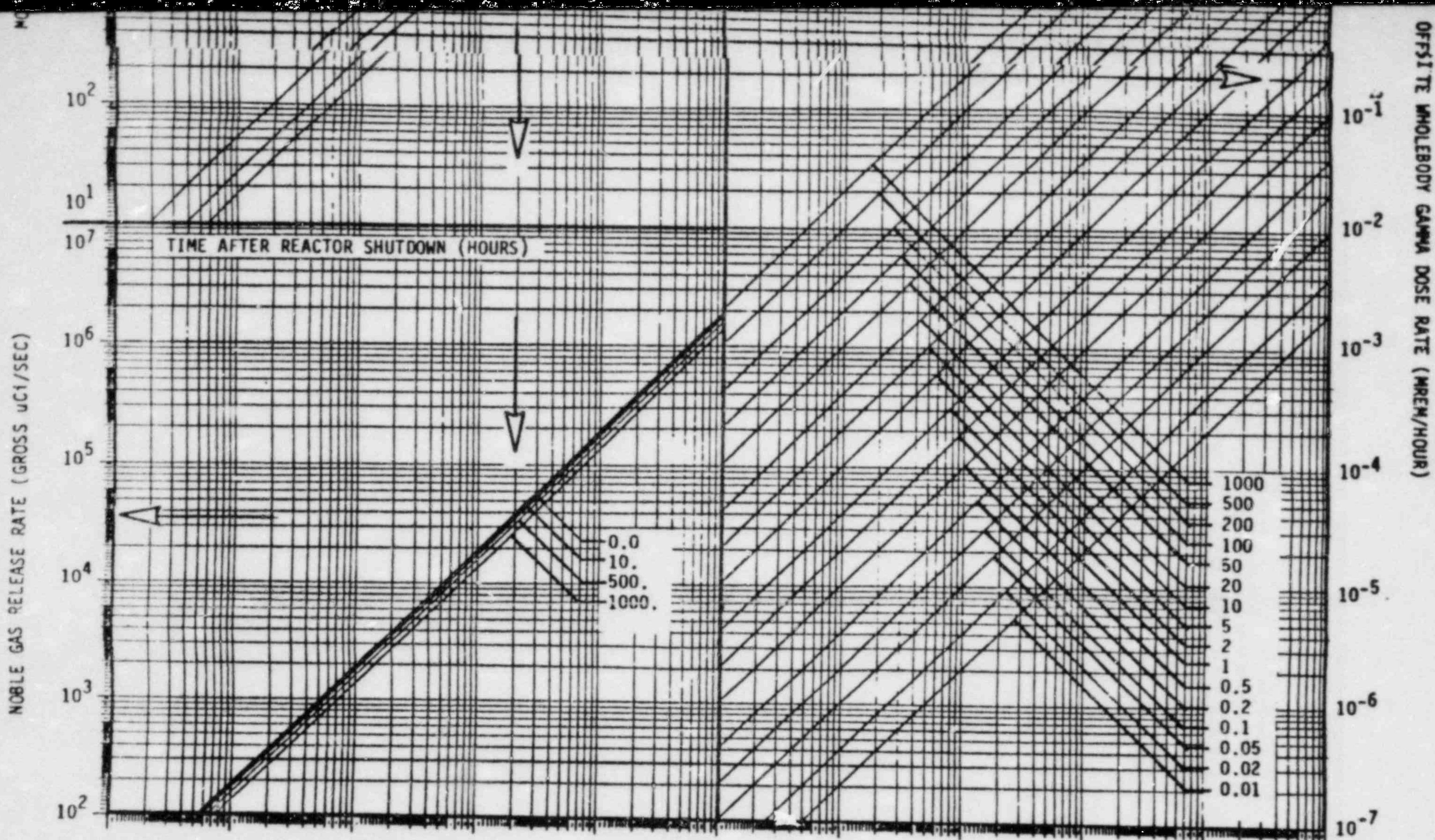
ELEVATED RELEASE (H = 140 M) - DIVIDE RESULTS BY ONE MILLION

MILES	A	B	C	D	E	F	G
.18	9.881	7.841	6.784	6.286	6.158	6.074	6.041
.25	10.931	8.998	7.408	6.460	6.247	6.108	6.057
.50	4.785	10.283	10.556	7.887	6.805	6.331	6.150
.75	1.245	6.662	10.612	9.371	7.655	6.634	6.283
1.0	.952	3.942	9.158	10.547	8.741	7.024	6.448
1.5	.886	1.530	6.357	10.770	10.499	8.108	6.835
2.0	.533	.773	4.512	9.651	10.931	9.381	7.274
2.5	.441	.600	3.345	8.341	10.621	10.273	7.766
3.0	.382	.506	2.578	7.195	10.007	10.714	8.358
3.5	.337	.440	2.050	6.247	9.307	10.908	8.825
4.0	.302	.392	1.671	5.475	8.619	10.917	9.442
4.5	.275	.355	1.387	4.840	7.976	10.784	9.890
5.0	.252	.325	1.173	4.320	7.395	10.562	10.247
7.5	.173	.234	.622	2.781	5.333	9.170	10.931
10.0	.138	.184	.397	1.984	4.072	7.888	10.670
15.0	.101	.128	.218	1.138	2.674	5.870	9.460
20.0	.079	.102	.151	.781	1.898	4.714	8.280
25.0	.065	.084	.116	.585	1.594	3.885	7.318
30.0	.057	.073	.101	.468	1.336	3.317	6.563
35.0	.050	.064	.089	.384	1.147	2.886	5.942
40.0	.045	.058	.079	.324	1.002	2.550	5.427
45.0	.041	.052	.071	.283	.894.	2.289	5.003
50.0	.038	.047	.064	.248	.803	2.070	4.637

SHOREHAM NUCLEAR POWER STATION

STATION VENT LOW-RANGE EFFLUENT MONITOR - WHOLEBODY GAMMA DOSE NOMOGRAM



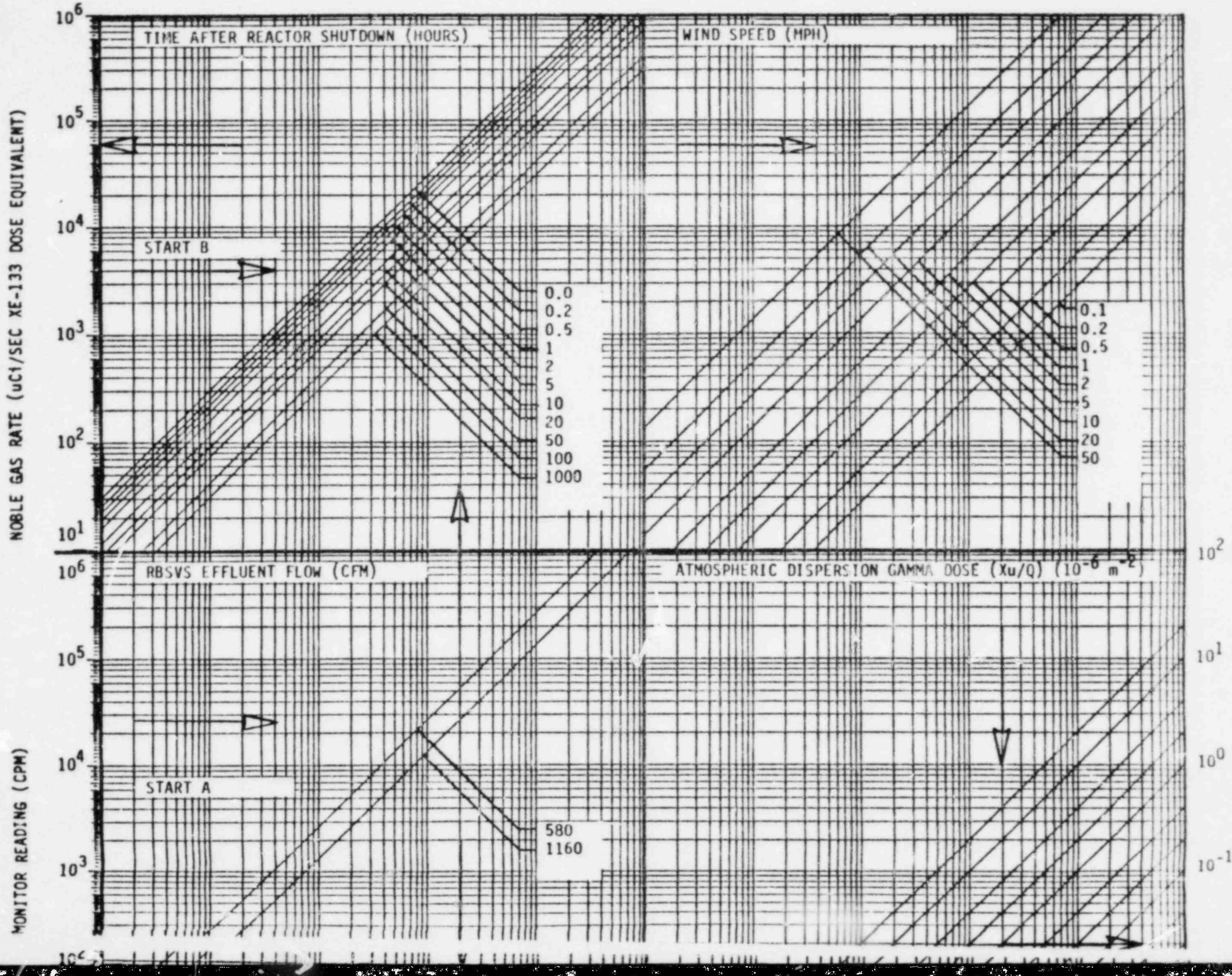


PRELIMINARY (MAY 17, 1982)

NOMOGRAM No. 1

SHOREHAM NUCLEAR POWER STATION

RBSVS LOW-RANGE EFFLUENT MONITOR - WHOLEBODY GAMMA DOSE NOMOGRAM



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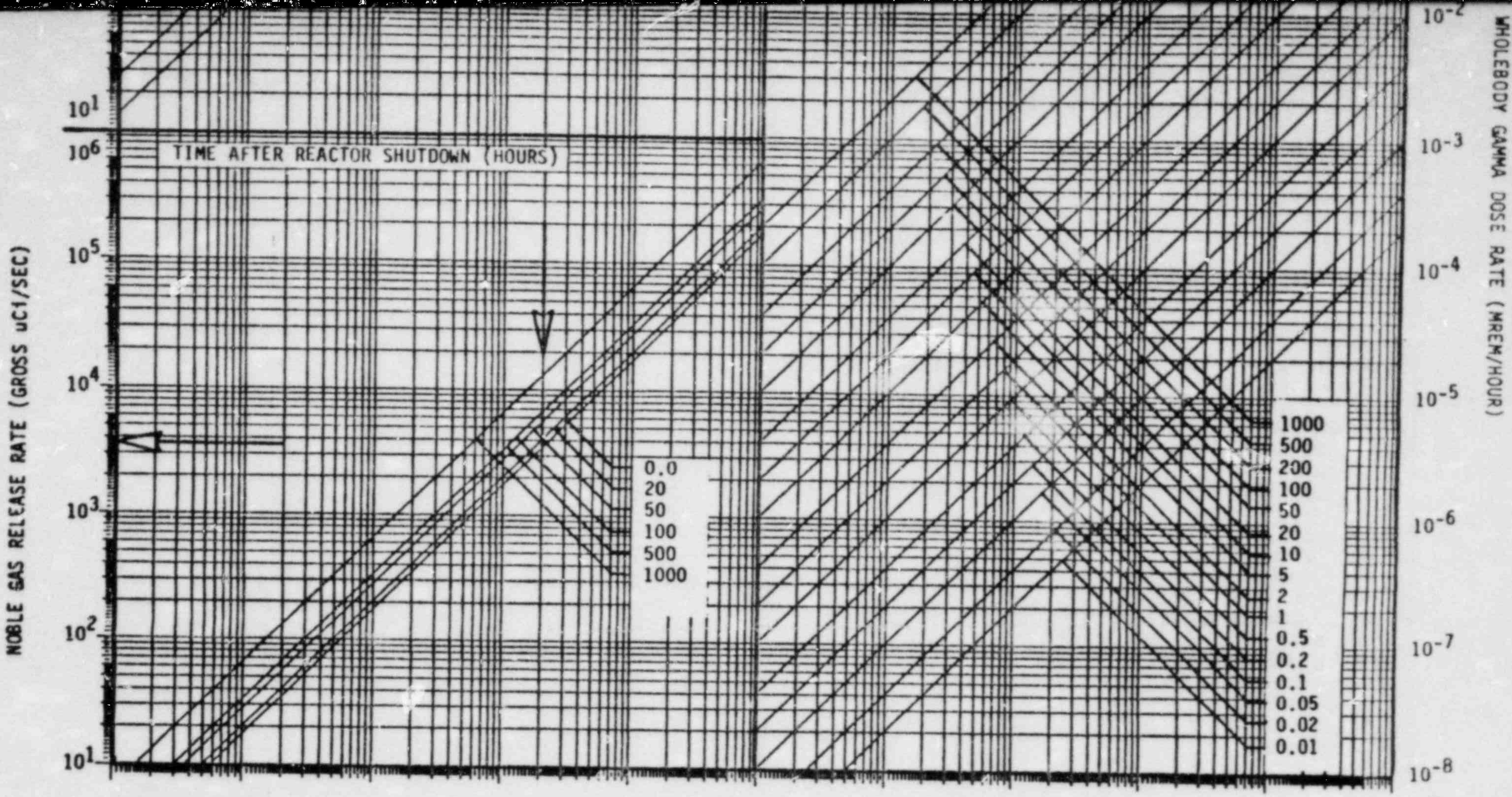

PRELIMINARY (MAY 17, 1982)

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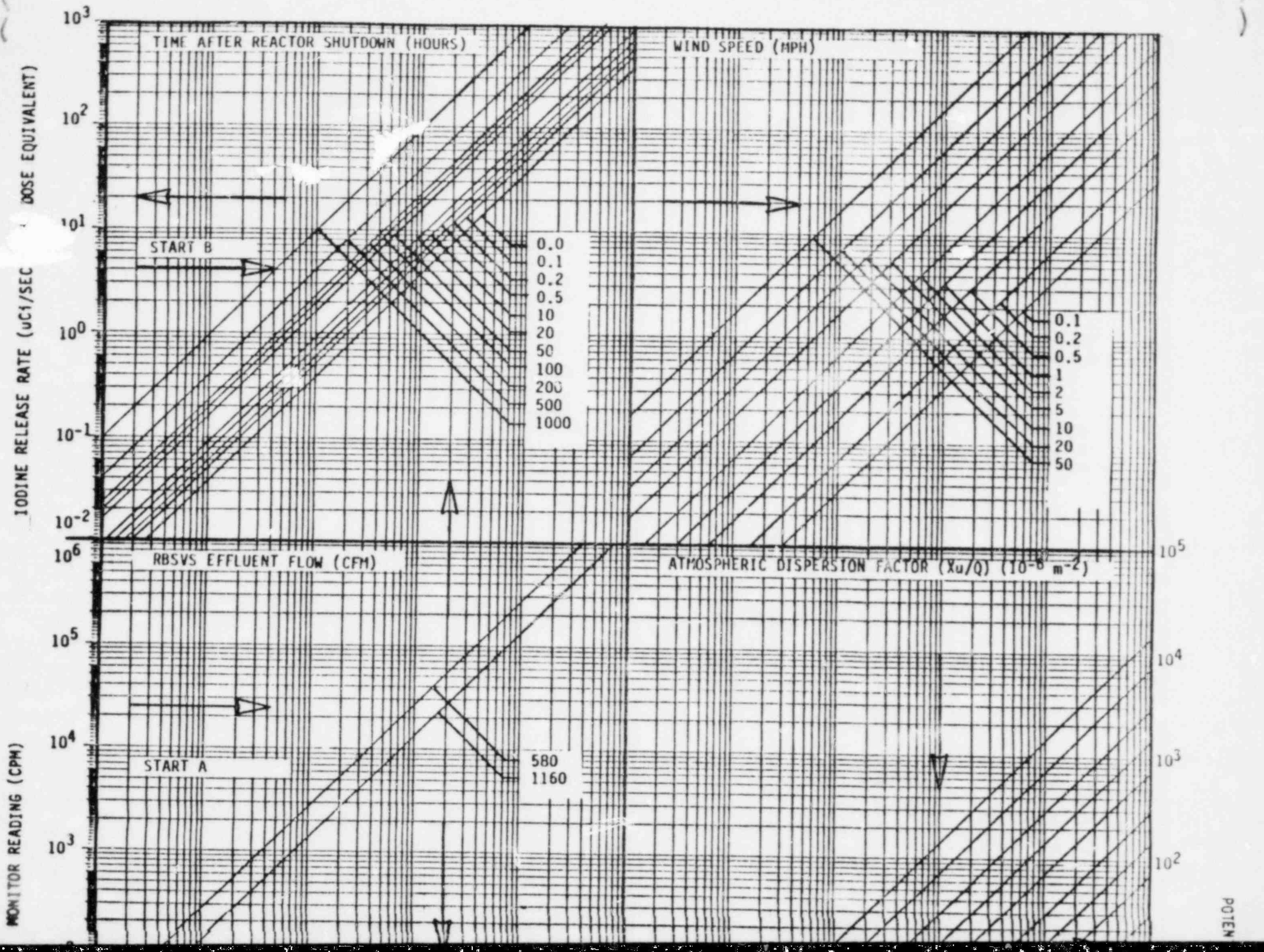
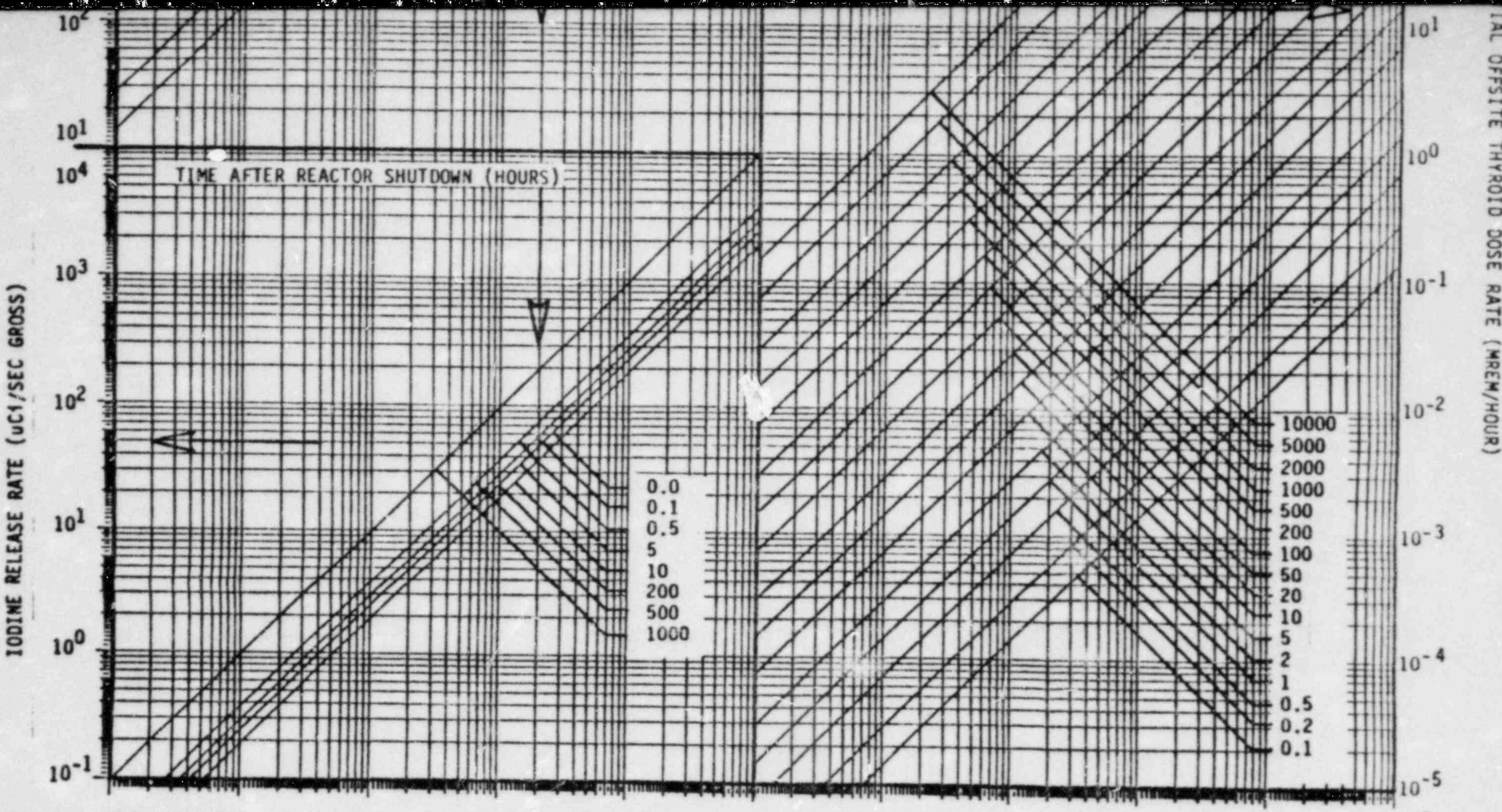
SHOREHAM NUCLEAR POWER STATION

RBSVS LOW-RANGE EFFLUENT MONITOR - POTENTIAL THYROID DOSE NOMOGRAM



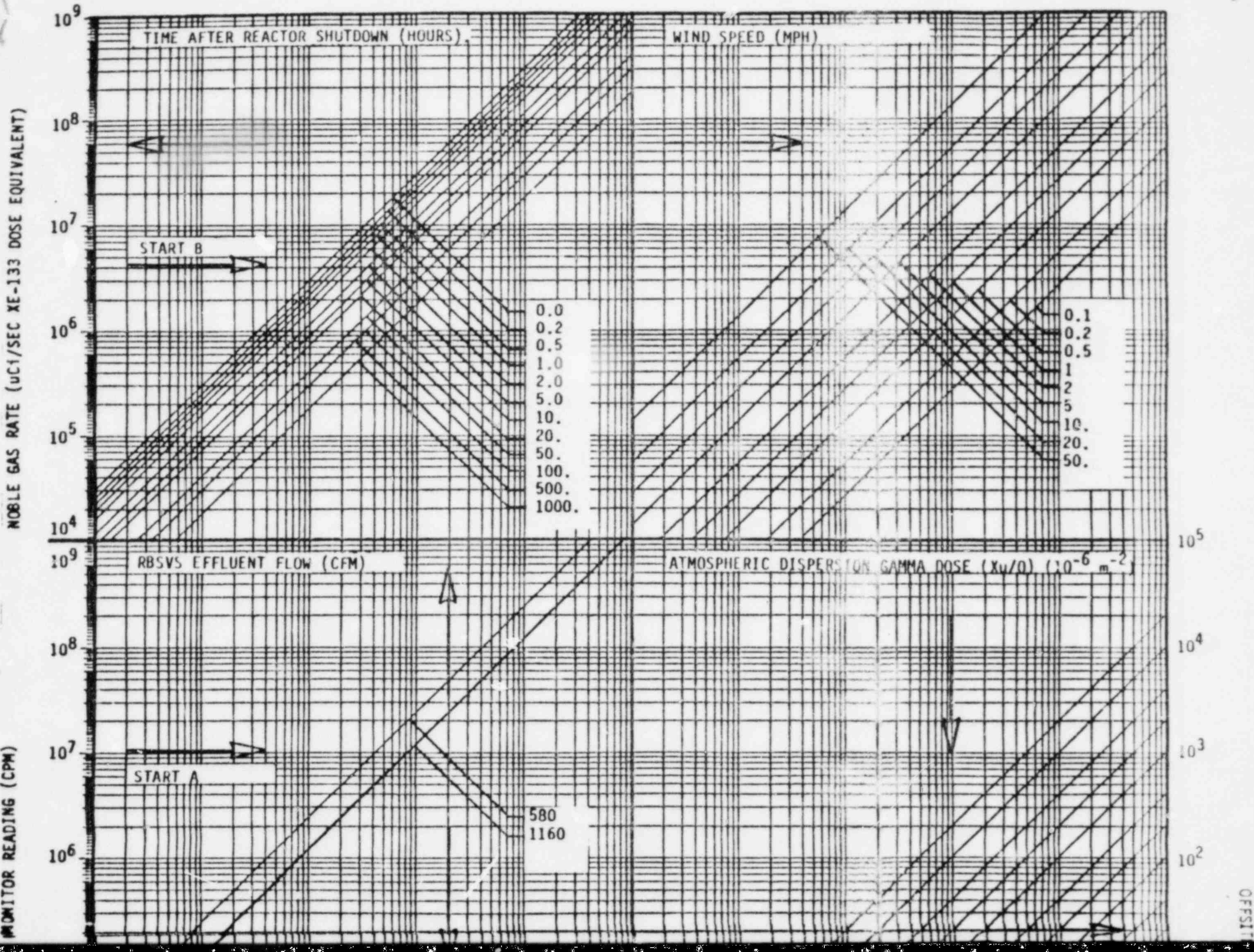


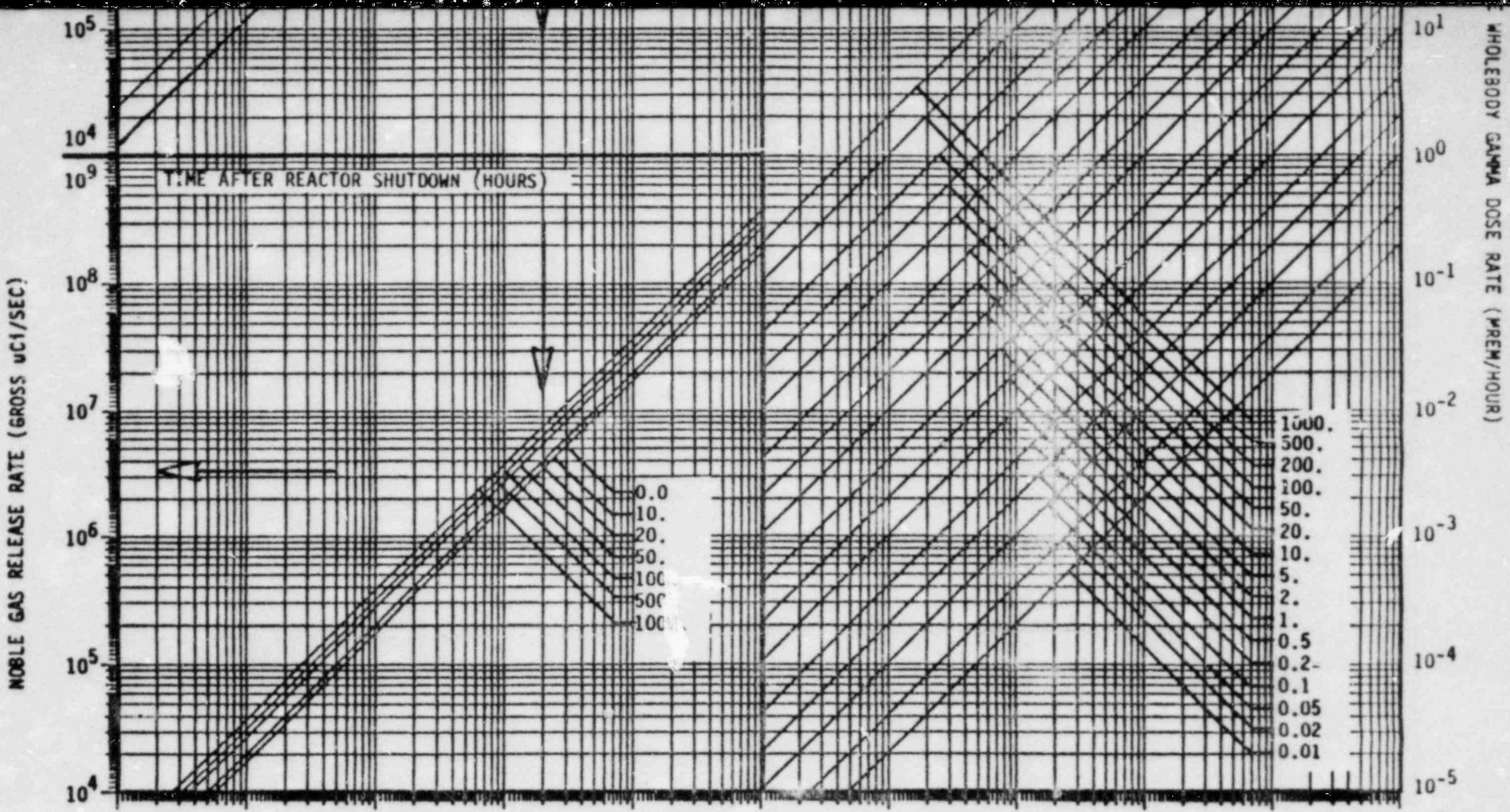
PRELIMINARY (MAY 17, 1982)

NOMOGRAM No. 4

SHOREHAM NUCLEAR POWER STATION

RBSVS INTERMEDIATE-RANGE EFFLUENT MONITOR - WHOLEBODY GAMMA DOSE NOMOGRAM



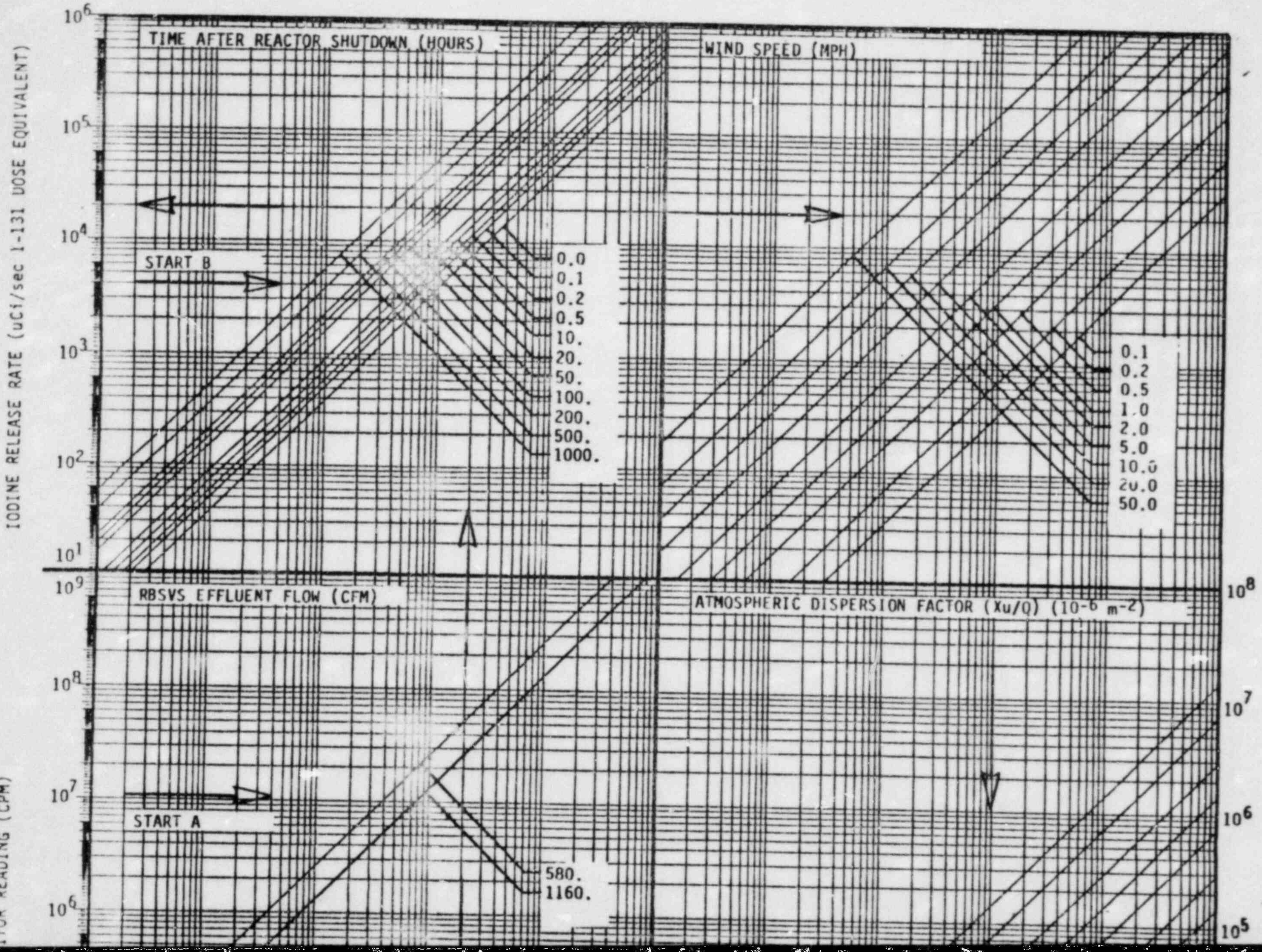


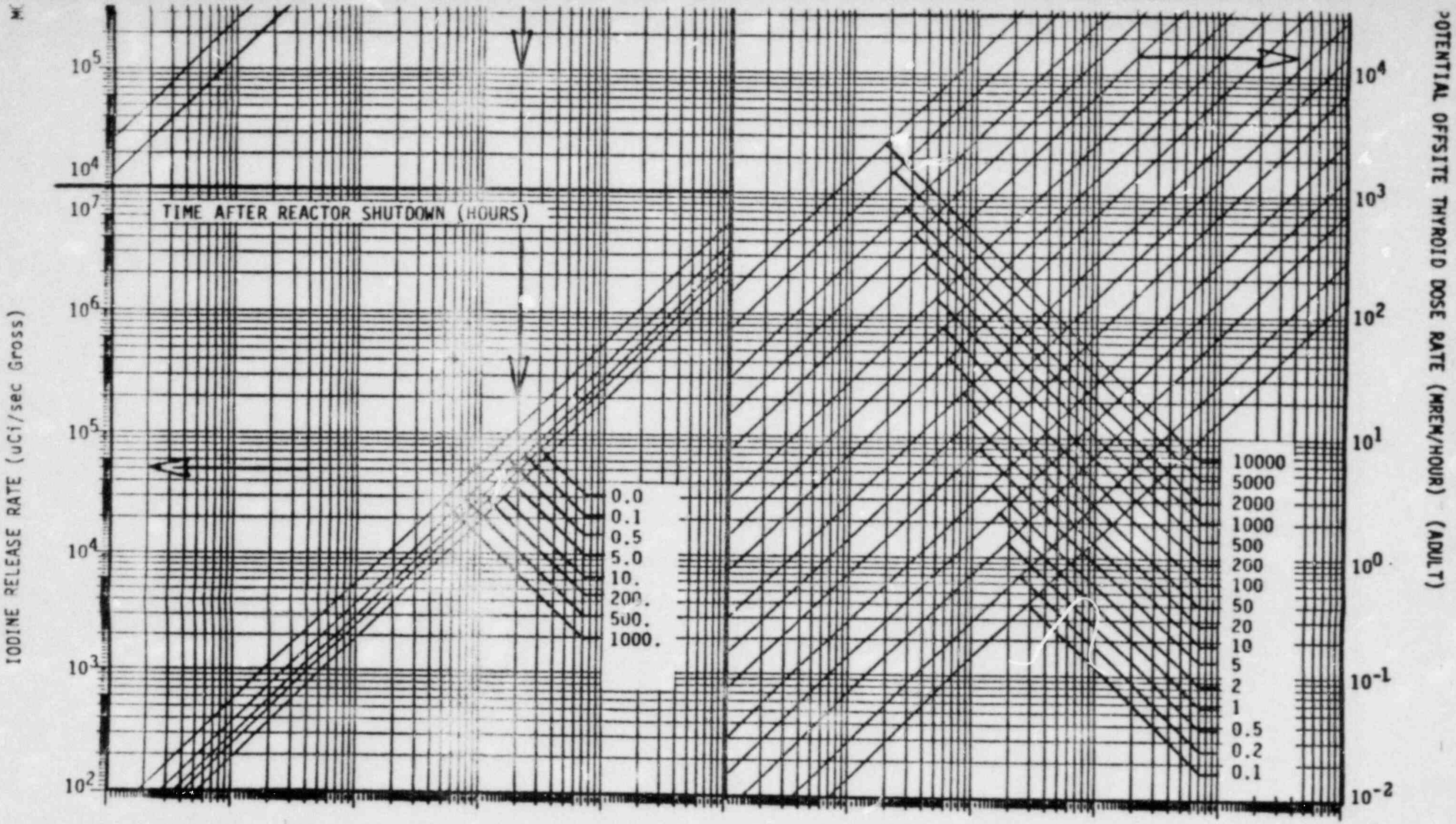
PRELIMINARY (MAY 17, 1982)

NOMOGRAM No. 5

SHOREHAM NUCLEAR POWER STATION

RBSVS INTERMEDIATE-RANGE EFFLUENT MONITOR - POTENTIAL THYROID DOSE NOMOGRAM





PRELIMINARY (MAY 17, 1982)

NOMOGRAM No. 6

Nomogram #2 (LATER)

Nomogram #7 (LATER)

Nomogram #8 (LATER)

SHOREHAM NUCLEAR POWER STATION

OFFSITE DOSE-ASSESSMENT METHODOLOGY FOR EMERGENCY APPLICATIONS

PAGE

SECTION 2

2.0 ATMOSPHERIC DISPERSION AND DOSE MODELS

This section describes the models employed in the evaluation of atmospheric dispersion of plant gaseous effluents and the ensuing radiological impact under accident conditions. The following radiation exposures are addressed:

- Thyroid dose exposure due to inhalation
- External wholebody gamma dose from overhead plumes (finite cloud modeling), and
- Skin beta-plus-gamma dose from overhead plumes (the beta and gamma components being based on the semi-infinite and finite cloud models, respectively).

With respect to atmospheric dispersion, two parameters will be described:

- The "concentration (χ/Q)", which converts effluent release rates of radioactivity to ground-level concentrations at receptors of interest, and
- The "gamma (χ/Q)", or $(\chi/Q)_\gamma$, which is used for the determination of external wholebody gamma doses from finite clouds of radioactive material.

Decay in transit and plume depletion due to ground deposition have been conservatively ignored.

In general, the equations given below represent the atmospheric dispersion and dose models in Regulatory Guides 1.109(2), 1.111(3) and 1.145(4), and in "Meteorology and Atomic Energy"(5). Some of the equations had to be restructured so as to accomodate the "gamma (χ/Q)" concept mentioned above.

2.1 THE DOSE-RATE EQUATIONS

By definition, the (χ/Q) is a measure of the ground-level relative airborne concentration of released radioactivity at a given distance from the source. That is, if the release rate is Q' (μCi/sec), then the airborne concentration at the receptor of interest is

$$\chi(\mu Ci/m^3) = Q'(\mu Ci/sec)\ (\chi/Q)\ (sec/m^3) \qquad (2.1)$$

Exposure to this concentration could result in both inhalation dose and external wholebody and skin doses. The basic equation for thyroid dose exposure is

$$D'_{thy} = (\chi/Q)\ B \sum_i Q'_i\ (DFT)_i \qquad (2.2)$$

where

D'_{thy} = thyroid dose rate (mrem/hr)

B = breathing rate (m^3/hr)

Q'_i = release rate of nuclide i to the atmosphere (μCi/sec)

$(DFT)_i$ = dose conversion factor for nuclide i (mrem per μCi inhaled).

The equations for wholebody gamma dose and skin dose due to a finite cloud of radioactive material have been expressed in the forms:

$$D'_{\gamma} = (\chi/Q)_{\gamma} \sum_i Q'_i\ (DFB)_i \qquad (2.3)$$

and

$$D'_{skin} = 1.11\ (\chi/Q)_{\gamma} \sum_i Q'_i\ (DF_{\gamma})_i + (\chi/Q) \sum_i Q'_i\ (DFS)_i \qquad (2.4)$$

where

D'_{γ} = wholebody gamma dose rate (mrem/hr)

D'_{skin} = skin dose rate (due to both gamma and beta radiation) (mrem/hr)

$(DFB)_i$ = gamma dose-to-body conversion factor for nuclide i (mrem/hr per $\mu Ci/m^3$)

$(DF_{\gamma})_i$ = gamma dose-to-air conversion factor for nuclide i (mrem/hr per $\mu Ci/m^3$)

and

$(DFS)_i$ = beta dose-to-skin conversion factor for nuclide i (mrem/hr per $\mu Ci/m^3$).

Note that these equations apply for both ground-level and elevated releases, the plume elevation, dimensions and gamma radiation spectra being properly accounted for by the "gamma (χ/Q)". In addition, the (χ/Q)'s represent either plume centerline or sector-average values, the former being for estimating instantaneous or short term dispersion effects, and the latter for dispersion during long periods of time. Decay in transit, plume depletion due to ground deposition and dose reduction due to the shielding effects of residential structures have been conservatively ignored. Detailed descriptions of the various dispersion models are presented in the sections which follow.

2.2 THE CONCENTRATION (χ/Q)

Equations are presented for both plume-centerline values (as would be needed for short-time interval applications and instantaneous dose rates) and sector-average values (as would be applicable for long-time intervals). All equations are based on the straight-line trajectory model with Gaussian dispersion, as described in Regulatory Guides 1.111(3) and 1.145(4).

2.2.1 Basic Equations

In contrast to Reg. Guide 1.111, where credit may be taken for partial plume entrainment by the wake effects of adjacent buildings the (conservative) approach followed here is that described in EPRI Report NP-1380(6). Specifically, the entrainment coefficient E_t can be either 1 (a fully entrained plume) or 0 (an elevated plume), and as a result the dispersion equations need not represent the mixed-mode option. The applicable (χ/Q) equations are therefore as follows:

- Ground-level plume-centerline:

$$(\chi/Q)^{pc} = \frac{1}{u_g(\pi\sigma_y\sigma_z + .B_w)}\,\xi_G \qquad (2.5)$$

or

$$(\chi/Q)^{pcm} = \frac{1}{\pi u_g M\,\sigma_y\,\sigma_z}\,\xi_M \qquad (2.6)$$

whichever yields the smaller value, the former accounting for building wake effects and the latter for plume meander credit.

- Elevated, plume-centerline:

$$(\chi/Q)^{pc} = \frac{1}{\pi u_e\sigma_y\,\sigma_z}\,\xi_E \qquad (2.7)$$

- Ground-level sector-average:

$$(\chi/Q)^{sa} = \frac{2.032}{u_g X \Sigma_z} \xi_G \qquad (2.8)$$

with the condition that

$$(\chi/Q)^{sa} \leq (\chi/Q)^{pc} \text{ and } (\chi/Q)^{pcm} \qquad (2.9)$$

- Elevated sector-average:

$$(\chi/Q)^{sa} = \frac{2.032}{u_e X \sigma_z} \xi_E \qquad (2.10)$$

In these equations, superscripts "pc", "pcm" and "sa" stand for "plume centerline", "plume centerline with plume meander", and "sector average", respectively. The remaining parameters are defined as follows:

X = downwind distance from release point (m)

u = wind speed (ground-level u_g or elevated u_e) (m/sec)

M = meander factor (a function of atmospheric stability and wind speed) (unitless)

σ_z = vertical plume standard deviation at distance X for the prevailing atmospheric stability (m)

σ_y = horizontal plume standard deviation at distance X for the prevailing atmospheric stability (m)

Σ_y = horizontal plume standard deviation corrected for building wake effects (m)

Σ_z = vertical plume standard deviation corrected for building wake effects (m)

ξ_G = reflection correction for ground level releases with building wake

ξ_M = reflection correction factor for ground-level releases with plume meander,

ξ_E = vertical attenuation and reflection correction for elevated releases, and

B_w = correction for building wake effects, defined as

$B_w = 0.5\ A$ or $B_w = 2\pi\sigma_y\sigma_z$

whichever is smaller, A being the cross-sectional area (in m^2) of the building causing the wake.

Unlike the regulatory guides, the equations given above also account for multiple eddy reflections of the radioactive pollutants between the ground and an iversion layer aloft. This is accomplished though the use of the ξ parameter and, as shown in Sec. 2.3.5 below, in limiting cases with relatively large vertical standard deviations, the desired result of uniform concentration in the vertical plane will be predicted.

Details on the various parameters are presented in the subsections which follow.

2.2.2 Plume Meander

According to Regulatory Guide 1.145(4), credit can now be taken for the benefit of plume meander in reducing offsite radiological impact predictions. The basis of this new position is recognition that dispersion models should provide more realistic, yet reasonably conservative, assessment of atmospheric dispersion. Figure 2.1 shows the curves recommended by the Commission for meander credit as a function of wind speed and atmospheric stability for distances up to 800 m. Beyond this distance, use is made of the adjusted meander factor defined as:

$$M' = (M-1)[\sigma_y(800)/\sigma_y] + 1 \qquad (2.11)$$

where $\sigma_y(800)$ is the horizontal plume standard deviation at a 800 m.

Note that for unstable conditions (stabilties A, B and C) and for wind speeds greater than 6 m/sec (independent of stability) the meander factor is equal to unity. In addition, the combined effects of plume meander and building wake are not allowed. Thus, in the plume centerline case, dilution factors are computed using both Eqs. (2.5) and (2.6) and then selecting the lesser value. Plume meander in not allowed for elevated releases.

2.2.3 Plume Standard Deviations and Building Wake

Values of σ_y and σ_z are computed through the use of 9-degree polynomials which were prepared to represent the data versus distance for the atmospheric stabilities A through G shown in Figs. 2.2 and 2.3 (from Ref. 4). σ_z values are restricted to a maximum value of 1000 m. For gound-level releases, consideration in also given to additional dispersion of the effluent plume within the wake caused by the buildings adjacent to the release point. The building wake correction factor B_w, as used in Eq. (2.5), represents the overall effect of the structure and does not differentiate between the horizontal and vertical components of the dispersion. This latter information is necessary for computing the sector-average (χ/Q)'s with building wake, the plume reflections between the ground plane and inversion layers aloft, and the lateral spread of the plume and its impact on off-center receptors. In such cases, use is made of the adjusted standard deviations defined as:

$$\Sigma_y = (\sigma_y{}^2 + 0.5A/\pi)^{1/2} \qquad (2.12)$$

and

$$\Sigma_z = (\sigma_z{}^2 + 0.5h_B{}^2/\pi)^{1/2} \qquad (2.13)$$

where

h_B is the height of the building causing the additional dispersion (m), and A is the smallest vertical cross-sectional area (m^2).

The maximum values of Σ_y and Σ_z are restricted by the conditions:

$$(\Sigma_y)_{max} = \sqrt{3} \quad \sigma_y \qquad (2.14)$$

and

$$(\Sigma_z)_{max} = \sqrt{3} \quad \sigma_z \qquad (2.15)$$

Recall that plume meander and building wake effects have been assumed to be mutually exclusive.

In the (χ/Q) equations, building wake effects were essentially represented by two models, one making use of parameter B_w for the overall combined effect, and one employing parameters Σ_y and Σ_z to account for the independent effects of the horizontal and vertical plume standard deviations. A comparison of a building wake formulation relying entirely on Σ_y and Σ_z with that in Reg. Guide 1.145 may be found in Ref. (7).

2.2.4 Entrainment

According to Reg. Guide 1.111, effluents can be considered to be ground level releases ($E_t = 1$), elevated releases ($E_t = 0$), or mixed-mode releases ($0 \leq E_t \leq 1$) depending on (a) the elevation of the release point above grade (h_s) relative to the height of adjacent solid buildings (h_B) and (b) the effluent exit velocity W_o relative to the speed of the prevailing speed during the period of interest. The alternatives are as follows:

- $h_s \leq h_B$ $\quad E_t = 1.0$ (2.16)
- $h_s \geq 2h_B$ $\quad E_t = 0.0$ (2.17)
- $h_B < h_s < 2h_B$ $\quad E_t = 1.0$ when $(R_v \leq 1)$ (2.18)
  $E_t = 2.58 - 1.58R_v$ when $(1 \leq R_v \leq 1.5)$ (2.19)
  $E_t = 0.3 - 0.06R_v$ when $(1.5 \leq R_v \leq 5)$ (2.20)
  $E_t = 0.0$ when $(R_v \geq 5)$

where

$$R_v = W_o/u_e \tag{2.21}$$

In contrast to the regulatory guide, as pointed out in Sec. 2.2.1 above, the approach employed in this work represents the findings of experimental results reported in Ref. (6). According to this reference, mix-mode releases cannot be justified, and for cases where $h_B < h_s < 2h_B$ the alternatives should be as follows:

- $h_B < h_s < 2h_B$ $\quad E_t = 1.0$ when $(R_v < 5)$ (2.22)
  $E_t = 0.0$ when $(R_v \geq 5)$ (2.23)

Under these restrictions, it is clear that the plume can be either at ground level or totally elevated at any one time.

2.2.5 Vertical Dispersion and Reflection

The ξ parameters in the (χ/Q) equations represent the exponential decrease in ground concentrations with increasing plume height, and the increase in concentration due to multiple eddy reflections from the ground and stable atmospheric layers aloft. Definition of these parameters was based on the plume trapping equations in the USEPA Workbook on Atmospheric Dispersion(8) as follows:

$$\xi_G = \sum_{j=-n}^{n} e^{-(\gamma j)^2} \tag{2.24}$$

$$\xi_M = \sum_{j=-n}^{n} e^{-(\beta j)^2} \tag{2.25}$$

$$\xi_E = \sum_{j=-n}^{n} e^{-(\alpha+\beta j)^2} \tag{2.26}$$

where

$$\alpha = \frac{h_e}{\sigma_z\sqrt{2}} \tag{2.27}$$

$$\beta = \frac{L\sqrt{2}}{\sigma_z} \tag{2.28}$$

$$\gamma = \frac{L\sqrt{2}}{\Sigma_z} \tag{2.29}$$

In these equations h_e is the effective plume height above ground, L is the depth of the mixing layer and 2n is the total number of reflections. n = 3 or 4 is normally sufficient to include the important reflections.

In case of large plume standard deviations, where multiple reflections occur and uniform vertical mixing has taken place, the equations reduce to simpler forms. For instance,

$$\text{limit } (\xi_E) = \int_{-\infty}^{\infty} e^{-(\alpha+\beta j)^2} \, dj = (1/\beta)\sqrt{\pi} \qquad (2.30)$$

and is achieved for σ_z greater than approximately 2L. Under these conditions Eq. (2.10) reduces to

$$(\chi/Q)^{sa} = \frac{2.55}{u_e \, X \, L} \qquad (2.31)$$

which is the familiar form of the sector-average dispersion equation with uniform vertical mixing.

2.2.6 Effective Plume Height

In accordance with Reg. Guide 1.111, the effective plume height is defined as

$$h_e = h_s + h_{pr} - h_t - c \qquad (2.32)$$

where

c = downwash correction factor for low relative exit velocity (see below) (m)

h_{pr} = plume rise above the release point (m)

h_s = physical height of the release point (m)

h_t = maximum terrain height (above the release-point grade elevation) between the release point and the receptor ($h_t > 0$) (m).

The downwash correction factor is defined as

$$c = 3(1.5 - R_v)d \qquad \text{when } R_v < 1.5 \qquad (2.33)$$

$$c = 0.0 \qquad \text{when } R_v \geq 1.5 \qquad (2.34)$$

where R_v is as defined in Sec. 2.2.4 and

d = inside diameter of the release vent.

In this application, due to the conditions imposed on the entrainment coefficient in Sec. 2.2.4 above, namely that an elevated release can occur only when $R_v \geq 5$, the downwash correction factor is always 0. In addition, since the resultant plume height in elevated releases is significantly higher than the surrounding terrain, the "h_t" parameter was redefined to represent the terrain height at the receptor of interest. Physically, this redefinition implies that the surrounding terrain will not have any impact on the elevation of the plume above MSL (mean sea level).

2.2.7 Plume Rise

Nuclear power plants normally have cold plumes, and hence only momentum plume-rise effects need be considered in the evaluation of the effective plume height. The applicable equations are as follows(9),(10):

- Neutral and unstable conditions

$$h_{pr} = 1.44\ R_v^{2/3}\ (X/d)^{1/3}\ d \qquad (2.35a)$$

or

$$h_{pr} = 3\ R_v\ d \qquad (2.35b)$$

whichever is smaller

- Stable conditions

$$h_{pr} = 1.44\ R_v^{2/3}\ (X/d)^{1/3}\ d \qquad (2.36a)$$

or

$$h_{pr} = 3\ R_v\ d \qquad (2.36b)$$

or

$$h_{pr} = 4\ (F_m / S)^{1/4} \qquad (2.37)$$

or

$$h_{pr} = 1.5\ (F_m / u_e)^{1/3}\ S^{-1/6} \qquad (2.38)$$

whichever is smaller, where

$$F_m = (W_o\ d / 2)^2 \qquad (2.39)$$

$$S = (9.81/T)\left[\frac{\partial T}{\partial z} + 0.0098\right] \qquad (2.40)$$

T = ambient air temperature (^{o}K)

Parameters X, d and R_v are as previously defined.

2.2.8 Mixing Depths

Vertical diffusion of the plume is inhibited by the existence of a stable atmospheric layer (an elevated inversion) aloft. The rate of vertical mixing is reduced in such cases and the stable layer can be considered as an effective lid on the vertical transport of pollutants.

The effect of plume trapping is included in the ξ terms discussed in Sec. 2.2.5, the depth of the mixing layer being represented by the symbol L. Low mixing depths should be selected for conservatism, typically 600 to 800 m.

2.2.9 Height-Dependent Wind Speeds

The extrapolation of wind speeds from the height at which the measurements are taken to a height of interest is accomplished through use of the equation

$$u_{new} = u_{old}\ (\ h_{new} / h_{old}\ )^q \qquad (2.41)$$

where

u_{old} = measured wind speed (m/sec)

u_{new} = extrapolated wind speed

h_{old} = height of wind speed instrument (m)

h_{new} = height of plume centerline above ground (m)

q = stability dependent power coefficient, equal to 0.25 for Pasquill stabilities A, B, C and D and equal to 0.50 for stabilities E, F, and G.

The parameters h_{old} and h_{new} must satisfy the conditions

$$h_{old} \geq 10 \text{ m} \tag{2.42}$$

and

$$h_{new} \geq 10 \text{ m} \tag{2.43}$$

and in extrapolating wind speeds to lower heights, u_{new} cannot become lower than some typical lower limit which is instrument specific (typically 0.5 mph).

2.3 THE FINITE-CLOUD GAMMA (χ/Q)

There are two models of interest to the nuclear power industry for the determination of external wholebody gamma exposures from gaseous effluents. Both models are described by D. H. Slade(5) In "Meteorology and Atomic Engery - 1968", and are as follows:

(a) The short-term Gaussian puff model with straight-line advection and off-axis receptors, and

(b) The long-term sector average model with uniform radioactivity distribution in the vertical plane.

The models are of interest because they are suitable for the evaluation of both ground-level and elevated plumes and also because they provide radiological impact assessments which are more realistic and less restrictive than those based on semi-infinite clouds with uniform concentration. In addition, they can provide more accurate interpretation of survey-team plume tracking measurements following accidental releases of radioactivity to the atmosphere.

2.3.1 Basic Equations

In both Gaussian puff and sector-average finite-cloud models, the final equations for external gamma exposure were expressed by Slade in simple form in terms of certain integrals I_1 and I_2 representing the spatial distribution of the radioactive material in the plume. As such, the equations do not explicitly include the χ/Q atmospheric dispersion term normally encountered in the equations for semi-infinite clouds.

The desire to have one form of equation which would apply for both finite and semi-infinite cloud models has prompted the definition by the author of the "gamma (χ/Q)" which is described in this section. Indeed, through the use of the concept, the finite cloud wholebody gamma dose equation takes the form

$$D'_\gamma = (\chi/Q)_\gamma \sum_i Q'_i \,(\mathrm{DFB})_i \qquad (2.44)$$

as given earlier in Eq. (2.3) and is identical in form to that for semi-infinite clouds with uniform concentration.

The "gamma (χ/Q)" is suitable for both ground-level and elevated releases and properly accounts for the gamma spectra associated with the airborne radioactivity. The final equation includes the weighted contribution of each gamma energy group as follows:

$$(\chi/Q)_\gamma = \frac{\sum_k \bar{E}_k \bar{A}_k (\chi/Q)^k_\gamma}{\sum_k \bar{E}_k \bar{A}_k} \qquad (2.45)$$

where

$$\bar{A}_k = \frac{\sum_i Q'_i A_{ki}}{\sum_i Q'_i} \qquad (2.46)$$

$$\bar{E}_k = \frac{\sum_i E_{ki} Q'_i A_{ki}}{\sum_i Q'_i A_{ki}} \qquad (2.47)$$

E_{ki} = actual energy of a gamma photon in group k emmitted by nuclide i (Mev)

A_{ki} = abundance of E_{ki}

Q'_i = release rate of nuclide i (µCi/sec), and

$(\chi/Q)^k_\gamma$ = finite cloud gamma (χ/Q) at photon energy E_k.

Definition of the last parameter depends on the finite-cloud model employed. For the plume centerline (or continuous puff) and sector average models in "Meteorology and Atomic Energy - 1968" (Ref. 5, Sections 7-5.2.2 and 7-5.2.5), the equations are as follows:

- Plume centerline model

$$(\chi/Q)_{\gamma}^{k} = \frac{2\,\mu\,\mu_a\,(I_1 + KI_2)}{\pi u} \qquad (2.48)$$

- Sector average model

$$(\chi/Q)_{\gamma}^{k} = \frac{2\,\mu_a\,(\bar{I}_1 + K\bar{I}_2)}{\sqrt{\pi}\,u\,X\,\Delta\phi} \qquad (2.49)$$

In these equations,

μ = linear air attenuation coefficient at E_k (1/m)

μ_a = linear air energy absorption coefficient at E_k (1/m)

$\Delta\phi$ = $\pi/8$ radians (the width of a 22.5° sector)

$K = (\mu - \mu_a)/\mu_a$ = buildup factor for air. (2.50)

I_1 and I_2 are the results of numerical integrations accounting for dispersion of the effluent plume, and are functions of the plume standard deviations, plume elevation, and photon energy, as defined in Ref. (5). They are discussed further in Sec. 2.3.2.

It is of interest to note that Eqs. (2.48) and (2.49) reduce to the "concentration (χ/Q)" equations for large plume standard deviations. This, by far, is one of the most interesting features of the "gamma (χ/Q)" as presently defined. Details are presented in the section which follows.

Application of the above equations requires knowledge of the gamma energy spectrum associated with the airborne radioactivity. In general, conservative results can be obtained by selecting a low-energy spectrum for ground-level releases and a relatively higher energy spectrum for elevated releases.

2.3.2 The Integrals I_1 and I_2

The finite-cloud models, and in particular the plume centerline (or continuous puff) model, have found only limited application primarily due to the mathematical complexity of the I_1 and I_2 integrals. A few years ago, values for these integrals were painstakingly extracted from 6-cycle log-log multi-plots in Ref. (5), an approach which is tedious, aggravating and susceptible to serious interpolation errors. Presently there exists two computer subroutines developed by the author$^{(11,12)}$ which provide an accurate determination of these integrals by fast numerical integration techniques. The integration model for the sector-average model presently forms part of Regulatory Guide 1.109$^{(2)}$. The plume centerline model was developed recently primarily due to its suitability in the implementation of emergency response plans.

Analytical descriptions of the finite cloud models may be found in Refs. (5), (9) and (10). For the purposes of this report, it suffices to note that the mathematical expressions for the integrals are as follows:

- Plume-centerline (continuous puff) model

$$I_1 = C \int_0^\infty \int_0^\infty \frac{\exp(-\mu r)}{mr} G(r,m)\, dr\, d(ut) \qquad (2.51)$$

$$I_2 \quad = \quad C\int_0^{\infty}\int_0^{\infty}\frac{\mu \ \exp(-\mu r)}{m} \ G(r,m) \ dr \ d(ut) \qquad (2.52)$$

$$G(r,m) \quad = \quad \exp\left[- \ \frac{(m-r)^2}{2 \ \sigma^2}\right] \ - \exp\left[- \ \frac{(m+r)^2}{2 \ \sigma^2}\right] \qquad (2.53)$$

$$C \quad = \quad (\ 4 \, \sigma \, \mu\sqrt{2\pi} \ )^{-1} \qquad \sigma \quad = \quad (\sigma_y \sigma_z)^{1/2} \qquad (2.54)$$

- Sector-average model

$$\bar{I}_1 \quad = \quad C \int_0^{\infty} G(z) \ E_1(\mu z) \ dz \qquad (2.55)$$

$$\bar{I}_2 \quad = \quad C \int_0^{\infty} G(z) \ \exp(-\mu z) \ dz \qquad (2.56)$$

$$G(z) \quad = \quad \exp\left[- \ \frac{(z-h)^2}{2 \ \sigma^2}\right] \ + \ \exp\left[- \ \frac{(z+h)^2}{2 \ \sigma^2}\right] \qquad (2.56)$$

$$E(\mu z) \quad = \quad \int_{\mu z}^{\infty} \frac{\exp(-\mu r)}{\mu r} \ d(\mu r) \qquad (2.57)$$

$$C \quad = \quad (2 \ \sqrt{2} \ \sigma_z)^{-1} \qquad (2.58)$$

For large plume standard deviations the I_1 and I_2 integrals reduce to the following limits (as shown in Refs. (11) and (12)):

- Plume Centerline (large [illegible]imit)

$$I_1 \quad = \quad I_2 \quad = \quad \frac{1}{2(\mu\sigma)^2} \ \exp \ (- \ 0.5 \ h_e^2/\sigma^2) \qquad (2.59)$$

- Sector-average (large σ limit)

$$\bar{I}_1 = \bar{I}_2 = \frac{1}{\sqrt{2}\ \mu\sigma_z} \exp(-\ 0.5\ h_e^2/\sigma_z^2) \qquad (2.60)$$

Under these conditions, the "gamma (χ/Q)" equations reduce to those for the concentration (χ/Q), as can be verified by substituting Eq. (2.59) into Eq. (2.48), and Eq. (2.60) into Eq. (2.49). Note however, that the "gamma (χ/Q)" equations do not account for the presence of an inversion layer aloft, and hence, in this application, one must also eliminate the reflection terms in the equations in Sec. 2.2.5 (i.e., one must also set $n = 0$). Within reasonable approximation, the multiple eddy reflections in the case of the gamma (χ/Q) equations can be handled by multiplying the results with the correction factor

$$\zeta_G = \xi_G \qquad (2.61)$$

for ground-level releases, and

$$\zeta_E = \exp(+\alpha^2)\ \xi_E \qquad (2.62)$$

for elevated plumes. For the sector-average gamma (χ/Q), parameters α, ξ_G and ξ_E are as defined in Sec. 2.2.5; for the plume-centerline case, it is also necessary to replace σ_z with the average plume standard deviation σ.

Graphical presentations of the integrals are shown in Figs. 2.4, 2.5, 2.6 and 2.7 (from Ref. 5).

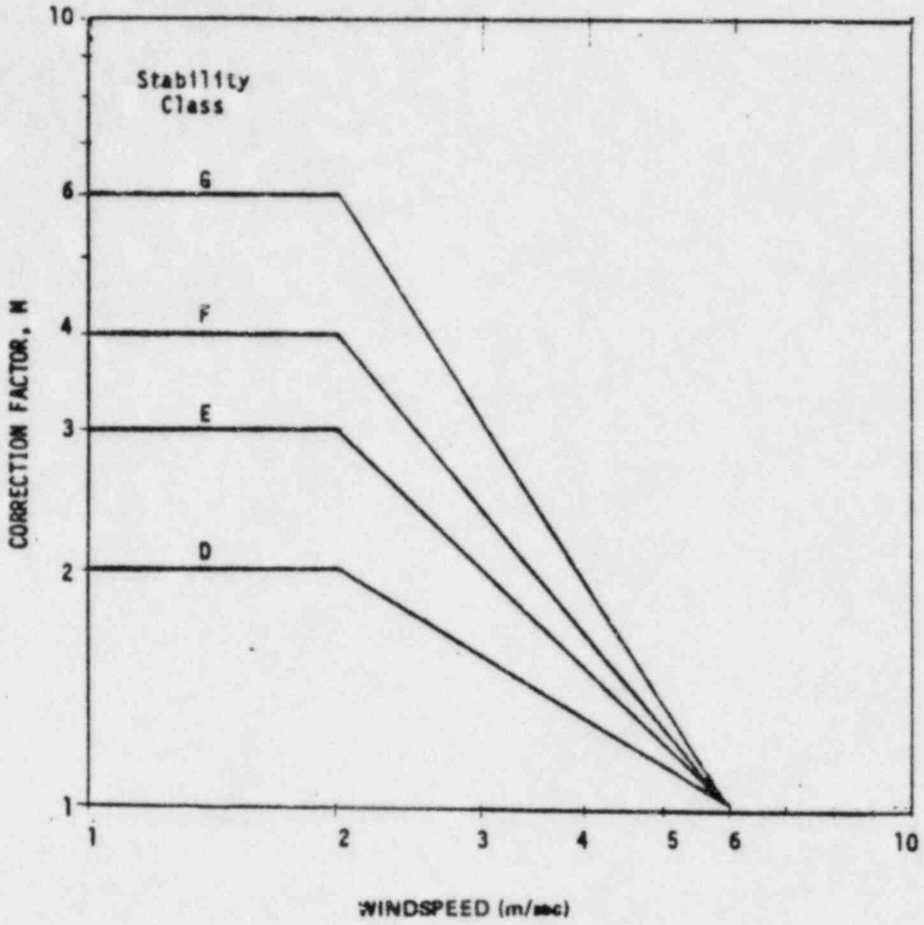


Fig. 2.1 Plume meander correction factor as a function of wind speed and stability (from Reg. Guide 1.145)

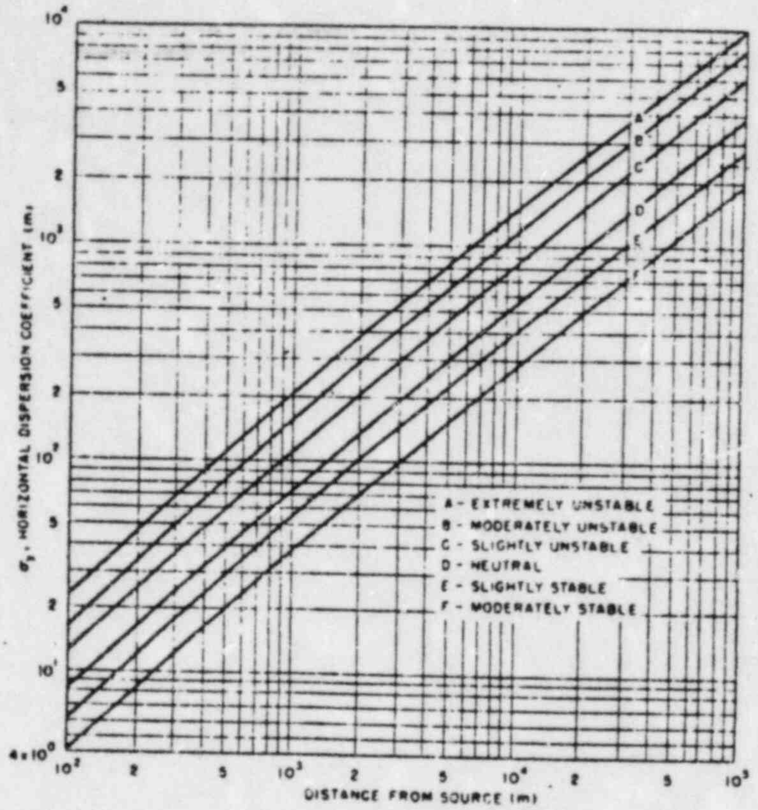


Fig. 2.2 Horizontal standard deviation of material in a plume (from Reg. Guide 1.145)

For purposes of estimating σ_y during extremely stable (G) atmospheric stability conditions, without plume meander or other lateral enhancement the following approximation is appropriate:

$$\sigma_y(G) = \frac{2}{3}\sigma_y(F)$$

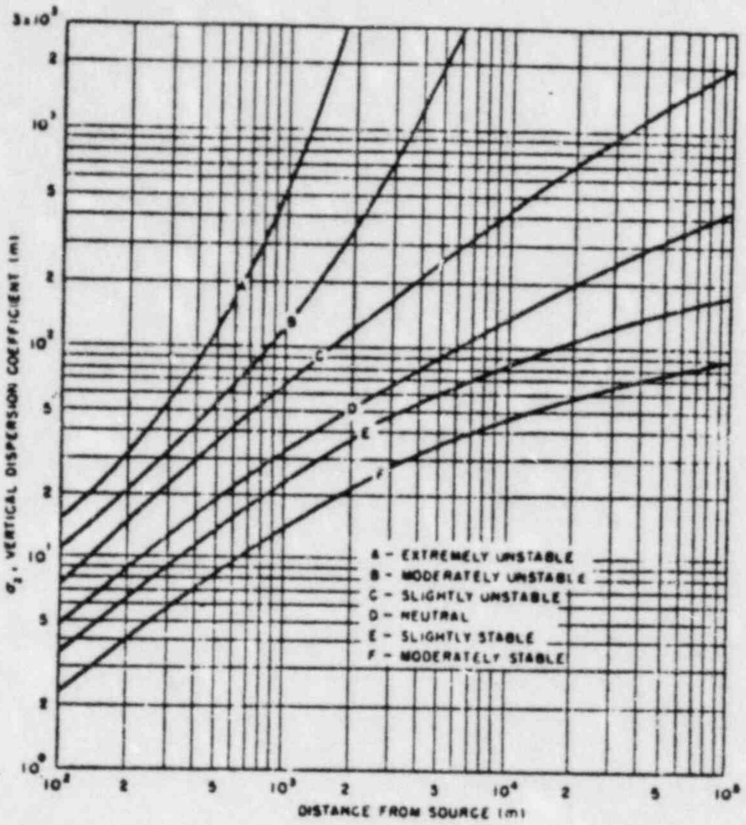


Fig. 2.3 Vertical standard deviation of material in plume (from Reg. Guide 1.145)

For purposes of estimating σ_z during extremely stable (G) atmospheric stability conditions, the following approximation is appropriate:

$$\sigma_z(G) = \frac{3}{5}\sigma_z(F)$$

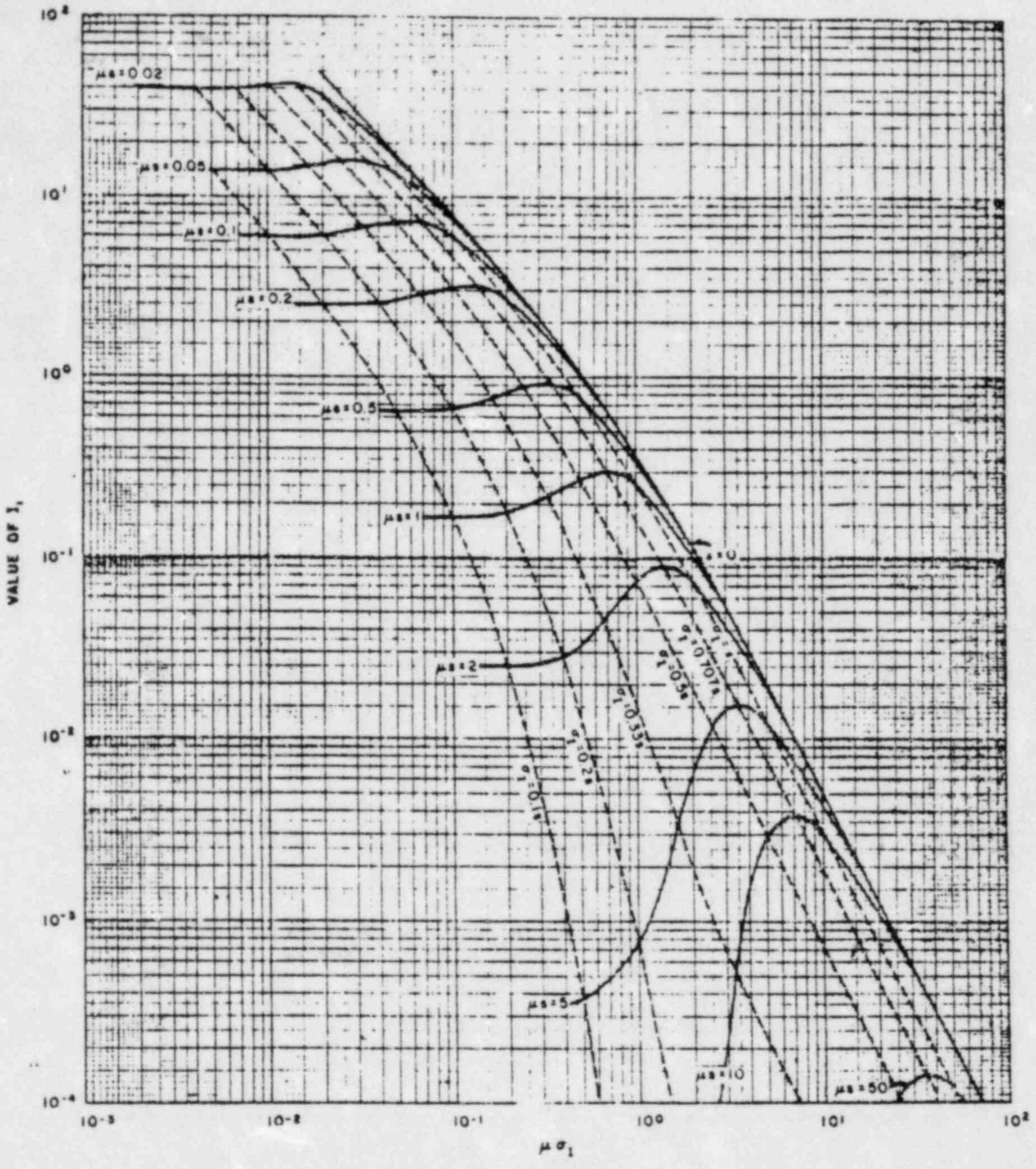


Fig. 2.4 Values of the I_1 integral (plume centerline or continuous puff model) (from Ref. 5)

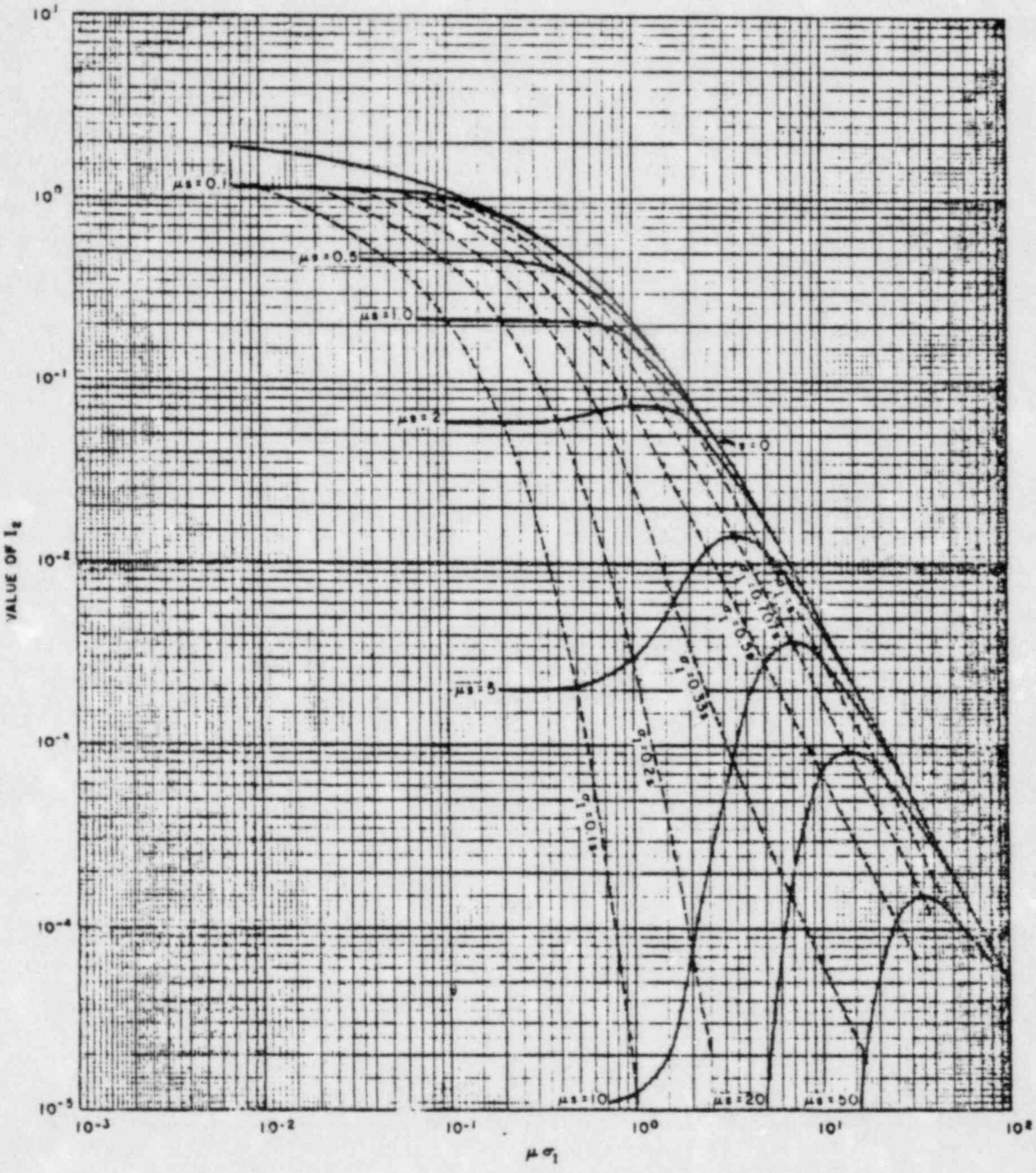


Fig. 2.5 Values of the I_2 integral (plume centerline or continuous puff model) (from Ref. 5)

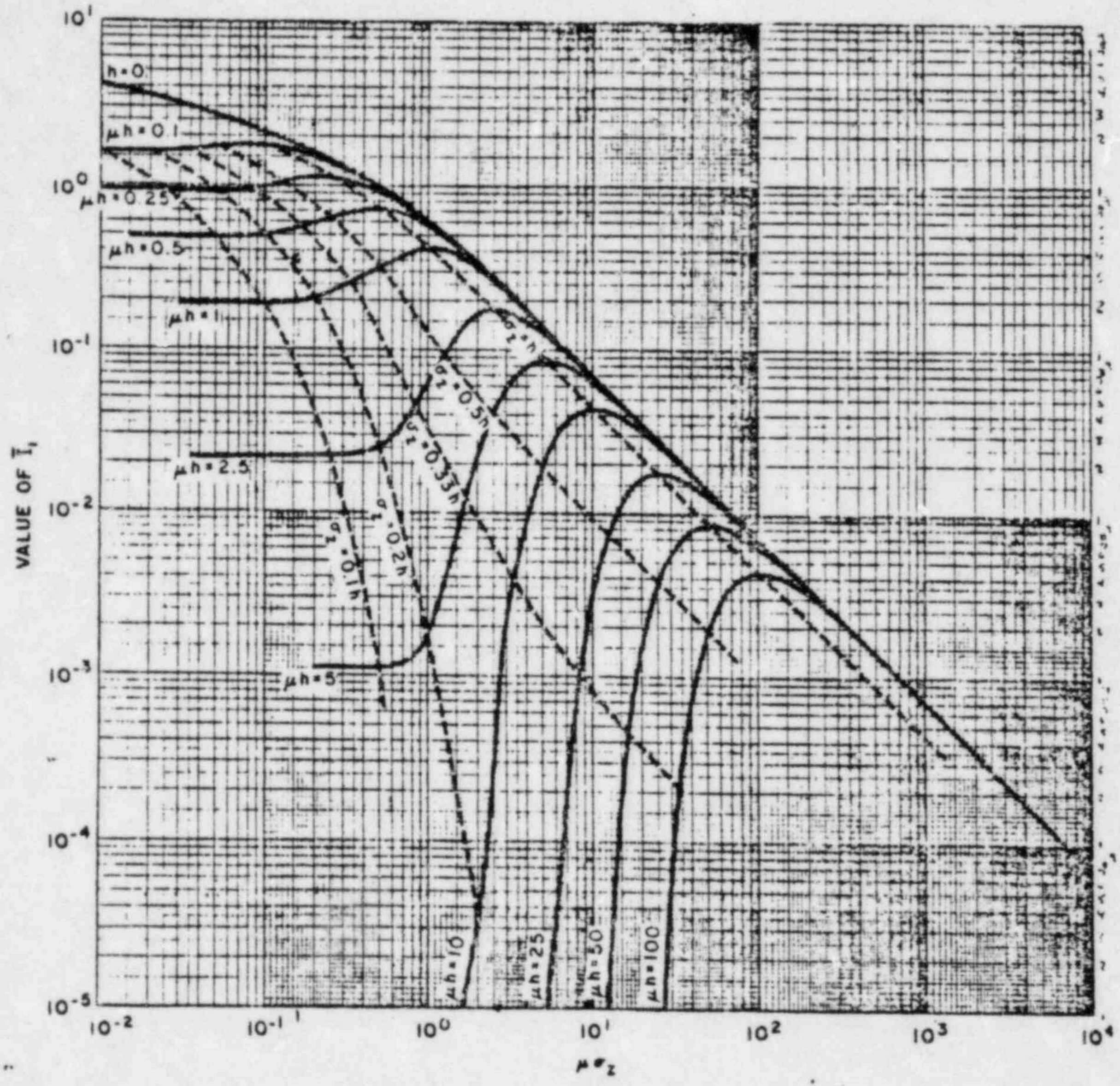


Fig. 2.6 Values of the I_1 integral (sector-average model) (from Ref. 5)

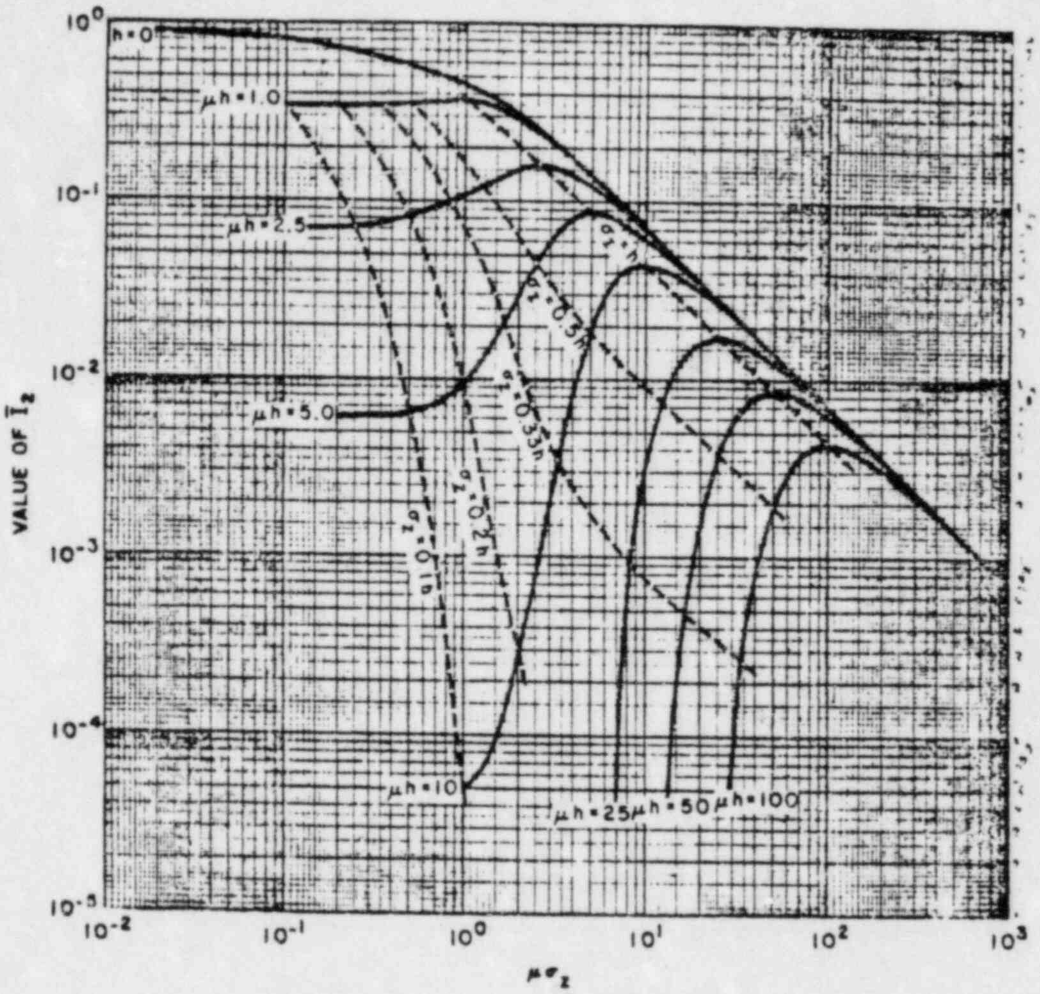


Fig. 2.7 Values of the I_2 integral (sector-average model) (from Ref. 5)

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LILCO, October 12, 1982

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CERTIFICATE OF SERVICE

In the Matter of
LONG ISLAND LIGHTING COMPANY
(Shoreham Nuclear Power Station, Unit 1)
Docket No. 50-322 (OL)

I hereby certify that copies of

EP 1(B)	"TESTIMONY OF WILLIAM G. SCHIFFMACHER AND WILLIAM F. RENZ FOR THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION 1(B) -- PROMPT NOTIFICATION SYSTEM"
EP 2(A)	"TESTIMONY OF ROGER E. LINNEMANN AND MICHAEL L. MIELE FOR THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION 2(A) -- ADEQUATE MEDICAL SERVICES"
EP 2(B)	"TESTIMONY OF NICHOLAS J. DI MASCIO AND EDWARD LIEBERMAN ON BEHALF OF THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION EP 2(B) -- GROUND TRANSPORTATION TO HOSPITAL"
EP 4	"TESTIMONY OF BRANT AIDIKOFF, H. MARK BLAUER, MATTHEW CORDARO, EDWARD LIEBERMAN, AND JAMES RIVELLO ON BEHALF OF THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION EP 4 -- PROTECTIVE ACTIONS"
EP 5(A)	"TESTIMONY OF MATTHEW C. CORDARO, RUSSELL R. DYNES, DENNIS S. MILETI, AND JAMES RIVELLO ON BEHALF OF THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION 5(A) -- ROLE CONFLICT"
EP 5(B)	"TESTIMONY OF NICHOLAS J. DI MASCIO AND EDWARD LIEBERMAN ON BEHALF OF THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION 5(B) -- TRAFFIC CONGESTION AFFECTING ONSITE EMERGENCY WORKERS AND OFFSITE LILCO PERSONNEL REPORTING TO THE SITE"

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EP 7(B)	"TESTIMONY OF H. MARK BLAUER, MATTHEW CORDARO AND JAMES RIVELLO ON BEHALF OF THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION EP 7(B) -- ABILITY TO AUGMENT WITHIN 30 MINUTES"
EP 10(B)	"TESTIMONY OF H. MARK BLAUER, MATTHEW C. CORDARO, AND JOHN F. SCHMITT FOR THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION 10(B) -- REAL TIME MONITORS"
EP 10(C)	"TESTIMONY OF JOHN F. SCHMITT AND JOSEPH S. BARON FOR THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION 10(C) -- ACCIDENT ASSESSMENT AND MONITORING"
EP 11(A), (B), (C)	"TESTIMONY OF WILLIAM F. RENZ AND PHILIP FRIEDMAN FOR THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION 11(A), (B), AND (C) -- COMMUNICATIONS WITH OFFSITE RESPONSE ORGANIZATIONS"
EP 13	"TESTIMONY OF JACK A. NOTARO AND ROBERT L. POLTRINO FOR THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION 13 -- INTERIM SAFETY PARAMETER DISPLAY SYSTEM"
EP 14	"TESTIMONY OF JOSEPH S. BARON, MATTHEW C. CORDARO, NICHOLAS J. DI MASCIO, JOHN N. HAMAWI, LOUIS P. POCALUJKA, AND JOHN F. SCHMITT ON BEHALF OF THE LONG ISLAND LIGHTING COMPANY ON PHASE I EMERGENCY PLANNING CONTENTION EP 14 -- ACCIDENT ASSESSMENT AND DOSE ASSESSMENT MODELS"

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