UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
DUKE POWER COMPANY, ET AL.	)	Docket Nos. 50-413
	)	50-414
(Catawba Nuclear Station,	)	
Units 1 and 2)	)	

NRC STAFF RESPONSES TO PALMETTO ALLIANCE SECOND SET OF INTERROGATORIES AND REQUESTS TO PRODUCE (PALMETTO CONTENTIONS 8 AND 27)

The Staff has previously indicated that it would voluntarily respond to Palmetto Alliance Second Set of Interrogatories and Requests to Produce, notwithstanding the provisions of 10 CFR Section 2.720(h)(2)(ii). The Staff herewith provides its answers and objections to the above discovery, which pertain to Palmetto Alliance contentions 8 and 27. The Staff has also served a Motion for Protective Order with respect to the instant objections, pursuant to 10 CFR Section 2.740(c).

As indicated in the following responses, the Staff objects to Interrogatories 1 and 36 on Contention 8, and Interrogatory 1 on Contention 27. Interrogatory 1 asks for identification of all "scientific, technical, and theoretical information on the subject of operator qualifications." Interrogatory 1 on Contention 27 is nearly identical, except that it relates to radiological detection and monitoring. Interrogatories phrased in terms of "all documents" related to a particular subject are not favored. Illinois Power Co. (Clinton Power Station, Units 1 and 2), ALAB-340, 4 NRC 27, 34 (1976). Inasmuch as no attempt is made to limit these interrogatories to material related to the underlying contention, there is no discernible limit on the scope of the request, making compliance with it extremely burdensome. Interrogatory 36 on Contention 8, seeking identification of "any documents, studies, comments or submissions known to you on this subject," is even broader and potentially more burdensome than the foregoing interrogatories. As has been noted in Boston Edison Company, et al. (Pilgrim Nuclear Generating Station, Unit 2), LBP-75-30, 1 NRC 579, 584 (1975):

> In general, it seems to be the weight of the holdings that, in the sound discretion of the court, a party may be protected against interrogatories where the answers would require an excessive or oppressive amount of research or compilation of data and at a great expense, although mere general objections that the interrogatories are onerous and burdensome are not sufficient. While a party must furnish in his answer to interrogatories whatever information is available to it, ordinarily it will not be required "to make research and compilation of data not readily known to him." (Footnote omitted.)

The subject interrogatories are thus objectionable for the very reason that they would require the Staff "to make research and compilation of data not readily know to [it]." Nevertheless, with respect to the interrogatories to which the Staff objects, the Staff has attempted to identify references to the principal documents on operator licensing and radiological monitoring of which it is aware.

All of the documents identified in responses to these interrogatories are either attached to these interrogatory responses or are available in the NRC Public Document Room, 1717 H Street, NW, Washington, DC, the local Public Document Room established in Rock Hill, South Carolina, or the recently created facility in Columbia, South Carolina. The interrogatory responses follow.

Respectfully submitted,

George E. Johnson
Counsel for NRC Staff

Dated at Bethesda, Maryland
this 19th day of October, 1982.

NRC STAFF ANSWERS TO PALMETTO ALLIANCE SECOND SET OF INTERROGATORIES ON CONTENTION 8

A. GENERAL INTERROGATORIES - CONTENTION 8

The following interrogatories apply severally to each of the contentions admitted as issues in controversy in this proceeding.

Q1. Please state the full name, address, occupation and employer of each person answering the interrogatories and designate the interrogatory or the part thereof he or she answered.

A1. Joseph Jean Buzy, 11709 Stonewood Lane, Rockville, Maryland 20852. Reactor Engineer, U.S. Nuclear Regulatory Commission. Interrogatories 1-36.

Q2. Please identify each and every person whom you are considering to call as a witness at the hearing in this matter on this contention, and with respect to each such person, please:

a. State the substance of the facts and opinions to which the witness is expected to testify;

b. Give a summary of the grounds for each opinion; and

c. Describe the witness' educational and professional background.

A2. This information will be provided after these determinations have been made.

Q3. Is your position on the contention based on one or more calculations? If so:

a. Describe each calculation and identify any documents setting forth such calculation.

b. Who performed each calculation?

c. When was each calculation performed?

d. Describe each parameter used in such calculation and each value assigned to the parameter, and describe the source of your data.

e. What are the results of each calculation?

f. Explain in detail how each calculation provides a basis for the issue.

A3. No calculations were performed.

Q4. Is your position on the contention based upon conversations, consultations, correspondence or any other type of communications with one or more individuals? If so:

a. Identify by name and address each such individual.

b. State the educational and professional background of each individual, including occupation and institutional affiliations.

c. Describe the nature of each communication with such individual, when it occurred, and identify all other individuals involved.

d. Describe the information received from such individuals and explain how it provides a basis for the issue.

e. Identify each letter, memorandum, tape, note or other record related to each conversation, consultation, correspondence, or other communication with such individual.

A4. No except as stated below.

a. Mr. Robert Sharpe, Licensing Manager, Duke Power Co., Charlotte, N.C.

b. See a. above.

c. In a telephone conversation, occurring on about September 15, 1982, Mr. Sharpe was consulted to learn the current status of Applicants' cold license training for Catawba personnel.

d. The information was used in answering several of the specific interrogatories with regard to simulator and site specific training of Catawba personnel.

e. Undated summary note contained on one page of notes made by Joseph Buzy. See Enclosure C.

B. <u>Specific Interrogatories</u> - <u>Contention 8</u>

Q1. Identify all documents, studies, technical reports and treatises that provide the applicant and/or subcontractors with scientific, technical, and theoretical information on the subject of operator qualifications.

A1. This interrogatory seeks an extensive amount of material and does not define limits on the subject of operator qualifications. The Staff therefore objects that this interrogatory is overly broad, and burdensome to answer. In addition, most if not all the material sought is not peculiarly in the possession of the NRC Staff. The interrogatory is therefore also objectionable as requiring the Staff to do extensive research and compilation of information not readily available to it. Notwithstanding these objections the Staff provides the following answer:

A large number of documents are referenced in the NRC sponsored report "Analysis, Conclusions and Recommendations Concerning Operator Licensing" NUREG/CR 1750, and in reference material in NUREG 0800, Chapter 13, Standard Review Plan. Further information is contained in the references of SECY-82-162 Report from the reactor operator qualifications Peer Review Panel.

Q2. Identify any and all communications with the NRC on the subject of operator qualifications. Include any and all communications with NRC on the subject of operator qualifications at all other nuclear facilities operated by the applicant as well as Catawba.

A2. Addressed to the Applicants.

Q3. Describe in detail the criteria used in selecting all control room personnel including but not limited to criteria concerning education, work experience, specialized training, physical and mental health, and personal characteristics. List the criteria for each position.

A3. Addressed to Applicants. The criteria used by NRC to evaluate control room personnel selection are found in Acceptance Criteria, Section II.G, of Chapter 13.1.2 - 13.1.3 of the Standard Review Plan (SRP) NUREG-0800. Section II.G refers to Regulatory Guide 1.8, "Personnel Selection and Training". Section 13.2.1, Reactor Operator Training, of the SRP provides criteria for operator training programs.

Q4. What are the bases for determining that the criteria identified in answer to No. 3, above, adequately forecast the person's ability to perform his or her job responsibilities?

A4. See answer to 3. Training programs have been upgraded as a result of TMI Action Plan and now require additional training during simulated accident conditions. The programs include simulator exercises which can observe and evaluate job performance.

Q5. Are the criteria described in question 3 required by any regulatory agency? Identify the relevant requirements and standards.

A5. Refer to answer 3 above. Relevant requirements are contained in 10 CFR Part 55, Operator's Licenses, of the NRC regulations. Standards are contained in NRC Regulatory Guides, Industry Standards and NUREGs referenced or contained in the Standard Review Plan.

Q6. Do the criteria described in question 3 meet or exceed the standards and requirements of the NRC and/or any other regulatory agency? If the answer is negative, where specifically are these criteria deficient?

A6. See answers 3-5 above.

Q7. Are any of the criteria described in question 3 additional to or different in any way from the required criteria? If so, describe in detail the additions or differences.

A7. See answers 3-6 above.

Q8. If the answer to question 7 is affirmative in whole or in part, why were such additions or changes made in the criteria used in selecting personnel. Identify any studies, documents, oral communications, testimony, memoranda and guidelines used in making the determination that such additions and/or changes would be useful in selecting control room personnel.

A8. Not applicable.

Q9. May any of the criteria described in your response to question 3 be waived in an individual case? If the answer is affirmative in whole or in part, describe in detail the circumstances under which the criteria may be waived.

A9. When an individual applies for a license, he or she may request waiver of examination and test requirements under conditions in Section 55.24 of 10 CFR Part 55, Operator's Licenses.

Q10. Have any criteria been waived in selecting control room personnel? If the answer is affirmative in whole or in part, describe in detail each instance where a waiver has been granted and give the reasons for such waiver. Are these waivers allowable under the relevant requirements and standards?

A10. The NRC is not aware of any waivers that may have been requested by the Applicants' staff.

Q11. In your FSAR 13 [illegible] you state:

"Operators, whether or not they are to be licensed by the NRC, should have a high school diploma, or equivalent, and should possess a high degree of manual dexterity and mature judgment."

a. Are all operators required to be licensed by the NRC? If not, describe in detail the job responsibilities of such operators. Why are they not required to be licensed by the NRC?

b. What is your understanding of "a high degree of manual dexterity"? Describe in detail methods used to determine if a person has such dexterity.

c. What is your understanding of "mature judgment"? Describe in detail the methods used and factors considered in determining if an applicant has "mature judgment".

A11. This interrogatory appears to be addressed to Applicants. The Staff nevertheless offers the following information:

a. Those personnel who must be licensed by the NRC are described in 10 CFR Part 55, Operator's Licenses, and in Section 50.54, Conditions of Licenses, of 10 CFR Part 50, Licensing of Production and Utilization Facilities. All personnel defined under 10 CFR Section 55.4 as "operators" are required to be licensed under that part.

b. Normally, nuclear power plants do not require continuous manual control or rapid response by the operators. Under abnormal conditions the operator's role is to back up automatic systems. If these systems fail to respond, rapid response is required by the operator to start and control the systems. Simulator exercises may be used to train and evaluate responses.

c. Mature judgment can be defined as the ability to anticipate and plan for scheduled evolutions and identify and respond to unplanned events. Simulator exercises can be used to demonstrate these qualities.

Q12. Do you contend that the experience levels now required by the NRC are sufficient to ensure that control room personnel are adequately prepared to respond in the event of an emergency? If the answer is negative, describe in detail the experience that should be required for each control room position.

A12. The NRC believes that experience and training levels described and/or referenced in Section 13.2.1 of the Standard Review Plan provides sufficient background for the operating staff to adequately respond to emergencies.

Q13. Do you contend that actual "hands-on" operating experience would not be beneficial to ensuring better performance by control room personnel? Explain in detail your answers.

A13. Hands on experience is beneficial and is included as part of the overall training program. Scheduled exercises during simulator training provide experience during normal, abnormal and emergency conditions. Additional hands-on experience at the Applicant plant is obtained during the startup test program.

Q14. Describe in detail the advantages and disadvantages of requiring hands-on operating experience for control room personnel.

A14. We believe there are no disadvantages in requiring hands-on experience. Operators who are required to manipulate or direct others to manipulate controls receive the following training: Simulator Experience - the operators, utilizing procedures, are trained to manipulate controls or direct others during normal, abnormal and emergency conditions. Few controls are required to be manipulated during response of emergency conditions since most safety systems respond automatically. During simulator training the operators become familiar with response of instrumentation during normal manipulation and are trained to diagnose abnormal and emergency conditions. Experience gained from simulator training is transferred to the plant on which the operator will be licensed. Operators are evaluated at each stage of their training program which involves demonstration of manipulative skills and diagnosing abnormal and emergency events.

Applicant Plant - The operators undergo an extensive training program on the Applicant's plant prior to assuming duties in the control room. The operators will gain experience using the equipment during the pre-startup test program and after fuel loading will gain additional experience during the power test program. The licensed operators are required to perform a prescribed number of manipulations using their plant or a simulator as part of their requalification program.

Q15. Explain in detail the bases for your answers to questions 1-14 above. List any documents, oral communications, or other information used in reaching the conclusions to your answers.

A15. Except as noted below, the previous answers contain the bases and requested information. Oral communication has been confined to a telephone conversation, approximately September 15, 1982, with Mr. Robert Sharpe, Licensing Manager at Duke Power. Mr. Sharpe provided information concerning the status of Applicants' cold license training for Catawba personnel.

Q16. Identify all control room personnel by name, position, educational level, experience and specialized training. [If experience, and/or training includes experience at other commercial or government reactors and/or simulators, identify the manufacturers, manufacturer's number, design model of each reactor and/or simulator.] Describe in detail the differences from each of these reactors or simulators to the facility at Catawba. Particularly describe in detail the differences in operating navy reactors and the Catawba reactor.

A16. a. The Applicants have supplied names, experience and training for some of their control room personnel in the FSAR. We do not have additional information.

b. Simulator training will be conducted on the McGuire simulator which has similar characteristics of the Catawba plant.

c. The differences in operating naval reactors and a large power plant as Catawba are that naval reactors are designed for rapid maneuvers whereas large power plants are designed to be operated at rated power. Rapid power changes at power reactors may be required during abnormal events; however, these events rarely occur.

Q17. Do you contend that these differences are significant regarding the ability of control room personnel to perform at Catawba? Explain in detail your answer.

A17. As discussed in answer to interrogatory 16, personnel trained and qualified at either type of reactor should be able to perform competently. Both types of reactors are similar in basic principles of operation. However, their operating characteristics differ since their design has different goals.

Q18. What are the bases for your answer to question 17? Identify all documents, oral communications, testimony or other information on which you relied.

A18. The answer of the Staff's respondent, Joseph Buzy, is based on 4 years association with the Naval Reactor Program, 3 years with the Air Force/AEC PM-1 Project and 19 years with the AEC/NRC, rather than upon particular documents, oral communications, testimony, etc.

Q19. Have control room personnel been involved in the planning of control room design and procedures? If so, explain in detail each person's participation.

A19. The Staff is not aware of individual participation in control room design or details of individual participation in developing procedures.

Q20. Describe in detail the training program required to be completed by all control room personnel.

A20. The Applicants' Training Program is contained in Chapter 13 of the FSAR. NRC will review the program in accordance with the SRP and will issue its findings in a Safety Evaluation Report (SER).

Q21. Do you contend that this program is sufficient to insure effective performance by such personnel during routine operation of the plant? Explain your answer in detail.

A21. The NRC position will be contained in the SER.

Q22. Do you contend that this program is sufficient to insure effective performance by such personnel in the event of an emergency situation? Explain in detail.

A22. The NRC position will be contained in the SER.

Q23. Do you contend that this program sufficiently compensates for actual hands on operating experience? Explain your answer in detail.

A23. The NRC position will be contained in the SER.

Q24. What are the bases for your answers to questions 20-23? Identify all documents, oral communication, testimony, physical evidence used.

A24. The NRC position will be contained in the SER.

Q25. Describe in detail the training received by control room personnel in emergency responses.

A25. The Applicants have presented the training program in the FSAR. The specific details of emergency response training are not contained in the FSAR. The NRC is evaluating the training program and will present its findings in the SER.

Q26. Is the training program above required or recommended by the NRC or any other regulatory agency? Cite the relevant requirements.

A26. The NRC position is stated in the SRP, and the Staff will present its findings in the SER.

Q27. Does the training program above meet or exceed the standards and/or requirements of the NRC and/or any other regulatory agency? If not, where specifically is your program deficient?

A27. The NRC position is stated in the SRP. The Staff's evaluation of Applicants' training program will be contained in the SER.

Q28. Has your program ever been evaluated? If so, describe in detail such evaluations.

A28. Directed to Applicants.

Q29. Has your program ever been criticized? If so, describe in detail such criticisms.

A29. Directed to Applicants.

Q30. Are any components of the training program described in your response to question 20 additional to or different in any way from the requirements of the NRC or any other regulatory agency? If so, describe in detail the additions and/or differences.

A30. Not applicable. See Staff response to interrogatory 20.

Q31. If the answer above is affirmative in whole or in part, why were such additions and/or changes made? Identify all studies, documents, oral communications and testimony used in making the determination that such changes and/or additions were necessary and/or useful in providing adequate training.

A31. Not applicable.

Q32. Identify by name, position, experience, educational level and specialized training all persons involved in training and instructing control room personnel.

A32. The Staff does not have this information.

Q33. Describe and identify all materials used in training personnel.

A33. The Staff does not have this information.

Q34. Describe in detail all tests given control room personnel during and following the training program.

A34. The NRC does not have tests which have been administered. The NRC will administer examinations under 10 CFR Part 55 when individuals apply for licenses.

Q35. Provide the tests results for all control room personnel.

A35. The NRC does not have any test results.

Q36. Describe in detail your involvement in any NRC rule making proceedings on the subject of operator qualifications and identify any documents, studies, comments or submissions known to you on this subject.

A36. Addressed to Applicants. See also answer to interrogatory 1.

NRC STAFF ANSWERS TO SECOND SET OF INTERROGATORIES ON PALMETTO ALLIANCE CONTENTION 27

A. GENERAL INTERROGATORIES - CONTENTION 27

The following interrogatories apply severally to each of the contentions admitted as issues in controversy in this proceeding.

Q1. Please state the full name, address, occupation and employer of each person answering the interrogatories and designate the interrogatory or the part thereof he or she answered.

A1. (a) Edward F. Branagan, Jr., Health Physicist with the Radiological Assessment Branch, USNRC, Washington, D.C. 20555. Interrogatories 1-9, 11-15, 17-19, 22-25, 27-28.

(b) Gerald E. Simonds, Physical Scientist, Emergency Preparedness Licensing Branch, USNRC, Washington, DC 20555. Interrogatories 2, 3, 4, 5, 16, 17, 18 (portions related to emergency preparedness).

Q2. Please identify each and every person whom you are considering to call as a witness at the hearing in this matter on this contention, and with respect to each such person, please:

a. State the substance of the facts and opinions to which the witness is expected to testify;

b. Give a summary of the grounds for each opinion; and

c. Describe the witness' educational and professional background.

A2. This information will be provided after these determinations have been made.

Q3. Is your position on the contention based on one or more calculations? If so:

a. Describe each calculation and identify any documents setting forth such calculation.

b. Who performed each calculation?

c. When was each calculation performed?

d. Describe each parameter used in such calculation and each value assigned to the parameter, and describe the source of your data.

e. What are the results of each calculation?

f. Explain in detail how each calculation provides a basis for the issue.

A3. No calculations were performed by the Staff.

Q4. Is your position on the contention based upon conversations, consultations, correspondence or any other type of communications with one or more individuals?

If so:

a. Identify by name and address each such individual.

b. State the educational and professional background of each individual, including occupation and institutional affiliations.

c. Describe the nature of each communication with such individual, when it occurred, and identfiy all other individuals involved.

d. Describe the information received from such individuals and explain how it provides a basis for the issue.

e. Identify each letter, memorandum, tape, note or other record related to each conversation, consultation, correspondence, or other communication with such individual.

A4. No. The Staff's position is based primarily on the following documents:

(1) The Branch Technical Position (BTP) of the NRC's Radiological Assessment Branch (Branch Technical Position, An Acceptable Radiological Environmental Monitoring Program, Rev. 1, November 1979). A copy of the BTP is Enclosure A.

(2) A document entitled "NRC Staff Motion for Summary Disposition of Contentions" Enrico Fermi Atomic Power Plant, Unit 2, Docket No. 50-341; Colleen P. Woodhead, Counsel for NRC Staff; attached affidavit by W. Wayne Meinke, Radiological Assessment Branch.

(3) Title 10, Code of Federal Regulations.

(4) Regulatory Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident", USNRC (December 1980).

(5) A document by W.J. Maeck, et al. entitled, "An Assessment Offsite, Real-Time dose Measurement Systems for Emergency Situations," NUREG/CR-2644, 1982. A copy of NUREG/CR-2644 is Enclosure B.

(6) NUREG-0654, Rev. 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants."

(7) Duke Power Company, Emergency Preparedness Plan and Implementing Procedures for Catawba Nuclear Power Plant.

B. SPECIFIC INTERROGATORIES

Q1. Identify all documents, studies, technical reports and treaties that provide the applicant and/or subcontractors with scientific, technical and theoretical information on the subject of radiation detection and radiological monitoring.

A1. The Staff is not aware of all the documents that were used by the applicant and/or subcontractors. However, the Applicants state in the Environmental Report (ER 6.1-16) that they used as guidance the following documents: (1) Environmental Radioactivity Surveillance Guide, ORP/SID 72.2; and (2) the Branch Technical Position (BTP) of the NRC's Radiological Assessment Branch (Branch Technical Position, An Acceptable Radiological Environmental Monitoring Program, Rev. 1, November 1979). A copy of the BTP is Enclosure A. To the extent this interrogatory seeks additional identification of materials it is objected to on grounds that the request is not readily definable, and would require an extraordinary amount of research and compilation of materials, not readily available to the Staff. As a result this request is overly broad and burdensome.

Q2. Describe in detail the purpose and component parts of an off site radiological monitoring system. Identify all requirements and standards applicable to this system.

A2. The purpose and components of the offsite radiological monitoring system are described in the BTP. The following regulations contain the principal requirements concerning radiological environmental monitoring: (1) 10 CFR 20.201(b); (2) 10 CFR 20.106(c)(6); (3) 10 CFR 50, Appendix I § IV.B; and 10 CFR Section 50.47(b).

Section 20.201(b) of 10 CFR requires each licensee to make surveys as necessary to comply with Part 20 regulations; and Section 20.106(c)(6) requires a description of environmental monitoring equipment and procedures to determine concentrations of radionuclides in unrestricted areas.

Section IV.B of Appendix I of Part 50 states:

"B. The licensee shall establish an appropriate surveillance and monitoring program to:

1. Provide data on quantities of radioactive material relesed in liquid and gaseous effluents to assure that the provisions of paragraph A of this section are met;
2. Provide data on measurable levels of radiation and radioactive materials in the environment to evaluate the relationship between quantities of radioactive material released in effluents and resultant radiation doses to individuals from principal pathways of exposure; and
3. Identify changes in the use of unrestricted areas (e.g., for agricultural purposes) to permit modifications in monitoring programs for evaluating doses to individuals from principal pathways of exposure."

In addition to these regulatory requirements, the BTP contains an example of the minimum radiological environmental program that is acceptable to the Staff.

Finally, 10 CFR 50.47(b) specifies the 16 planning standards for onsite and offsite emergency response plans for nuclear power reactors. Those that address offsite radiological monitoring system (and the related acceptance criteria of NUREG-0654) are:

(a) <u>Emergency Response Support and Resources</u> (§50.47(b)(3))

<u>Planning Standard</u>

Arrangements for requesting and effectively using assistance resources have been made, arrangements to accommodate State and local staff at the licensee's near-site Emergency Operations Facility have been made, and other organizations capable of augmenting the planned response have been identified.

<u>Acceptance Criteria (NUREG-0654)</u>

1. The Federal government maintains in-depth capability to assist licensee, States and local governments through the Federal Radiological Monitoring and Assessment Plan (formerly Radiological Assistance Plant (RAP) and Interagency Radiological Assistance Plan (IRAP). Each State and licensee shall make provisions for incorporating the Federal response capability into its operation plan.

* * *

3. Each organization shall identify radiological laboratories and their general capabilities and expected availability to provide radiological monitoring and analyses services which can be used in an emergency.

(b) <u>Emergency Facilities and Equipment</u> (§50.47(b)(8))

<u>Planning Standard</u>

Adequate emergency facilities and equipment to support the emergency response are provided and maintained.

Acceptance Criteria (NUREG-0654)

* * *

6. Each licensee shall make provisions to acquire data from or for emergency access to offsite monitoring and analysis equipment including:

* * *

b. radiological monitors including ratemeters and sampling devices. Dosimetry shall be provided and shall meet, as a minimum, the NRC Radiological Assessment Branch Technical Position for the Environmental Radiological Monitoring Program; and

* * *

7. Each organization, where appropriate, shall provide for offsite radiological monitoring equipment in the vicinity of the nuclear facility.

12. Each organization shall establish a central point (preferably associated with the licensee's near-site Emergency Operations Facility, for the receipt and analysis of all field monitoring data and coordination of sample media. (Emphasis added.)

(c) Accident Assessment (Section 50.47(b)(9))

Planning Standard

Adequate methods, systems and equipment for assessing and monitoring actual or potential offsite consequences of a radiological emergency condition are in use.

Acceptance Criteria (NUREG-0654)

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4. Each licensee shall establish the relationship between effluent monitor readings and onsite and offsite exposure and contamination for various meteorological conditions. (Emphasis added.)

*　　　*　　　*

7. Each organization shall describe the capability and resources for field monitoring within the plume exposure Emergency Planning Zone which are an intrinsic part of the concept of operations for the facility.

8. Each organization, where appropriate, shall provide methods, equipment and expertise to make rapid assessments of the actual or potential magnitude and locations of any radiological hazards through liquid or gaseous release pathways. This shall include activation, notification means, field team composition, transportation, communication, monitoring equipment and estimated development times.

9. Each organization shall have capability to detect and measure radioiodine concentrations in air in the plume exposure EPZ as low as 1^7 uCi/cc (microcuries per cubic centimeter) under field conditions. Interference from the presence of noble gas and background radiation shall not decrease the stated minimum detectable activity.

11. Arrangements to locate and track the airborne radioactive plume shall be made, using either or both Federal and State resources.

(d) Protective Response (Section 50.47(b)(10))

Planning Standard

A range of protective actions have been developed for the plume exposure pathway EPZ for emergency workers and the public. Guidelines for the choice of protective actions during an emergency, consistent with Federal guidance, are developed and in place, and protective actions for the ingestion exposure pathway EPZ appropriate to the locale have been developed.

Acceptance Criteria (NUREG-0654)

* * *

10. The organizations' plans to implement protective measures for the plume exposure pathway shall include:

a. Maps showing evacuation routes, evacuation areas, preselected radiological sampling and monitoring points, relocation centers in host areas, and shelter areas; (identification of radiological sampling and monitoring points shall include the designators in Table J-1 or an equivalent uniform system described in the plan).

Q3. Describe in detail the offsite radiological monitoring system to be installed at Catawba. Does this system meet and/or exceed the requirements and standards identified above. Discuss in detail any deviation, deficiency and/or addition to the requirements and standards identified above.

A3. The offsite radiological monitoring program is described in §5.9.3.4 of the DES, and in §6.1.5 and 6.2.1 of the Applicants' Environmental Report. Staff review of the Applicants' offsite radiological monitoring program is presented on page 5-24 of the DES. With respect to compliance with emergency planning requirements (see A2. above), Applicants' offsite radiological monitoring system, discussed in the Emergency Plan and Emergency Implementing Procedures, is under review at the present time. The results of the review will be published in the SER.

Q4. Are there any other methods available for meeting the standards and requirements above? Identify all other methods.

A4. Methods for meeting the requirements of the applicable regulations are described in the BTP and in NUREG-0654.

Q5. Describe in detail the functions and detection capabilities of the offsite radiological monitoring system to be installed at Catawba.

A5. See response to Interrogatory 3. In addition, the Emergency Plan for Catawba in Section H. paragraph 6.b, states that:

> Environmental Radiological Monitoring equipment includes five radio- and particulate continuous air samplers and forty thermoluminescent dosimeters. The thermoluminescent dosimeters are posted and collected in accordance with Table 1, Branch Technical Position, Rev. 1 of November, 1979. Figure H-15 and H-16 lists locations of posted thermoluminescent dosimeters and air samplers.

Q6. What is the cost of the system to be installed at Catawba? Include cost of all component parts, installation costs, operating costs, costs involved in collecting the data, costs of processing the data as well as any other costs associated with the system.

A6. The Staff does not have the information requested because the applicant selects the system for a particular plant.

Q7. Describe in detail the process followed in selecting the components of the offsite radiological monitoring system to be installed at Catawba. Identify in your response all manufacturers consulted, models of components considered, costs of such components, capabilities of such components, studies, documents, oral communications, and testimony used in the process of selecting this system.

A7. The Staff does not have the information requested because the applicant selects the system for a particular plant.

Q8. Specify your reasons for rejecting other components considered.

A8. The Staff does not have the information requested because the applicant selects the system for a particular plant.

Q9. Do you contend that thermoluminescent dosimeters (TLDs) are superior to any other method of radiological monitoring? Describe in detail how TLDs are superior or inferior to other methods of monitoring.

A9. The Staff's position is described in the BTP (p. 9, footnote f).

Q10. Identify any and all communications with the NRC on the subject of offsite radiological monitoring systems. Include communications about the offsite radiological monitoring systems at other nuclear plants operated by Duke in addition to those concerning Catawba.

A10. Directed to Applicants.

Q11. Describe in detail the offsite radiological monitoring system in use at all other nuclear facilities operated by the Applicants. Explain any differences between the systems at all other facilities and the system to be installed at Catawba.

A11. Duke Power company operates two other nuclear facilities: (1) Oconee Units 1, 2, & 3; and (2) McGuire Units 1&2. A description of the offsite radiological monitoring programs, as well as annual environmental radiological monitoring reports, can be obtained from the local Public Document Rooms: (1) Oconee County Library, 201 S. Spring Street, Walhalla, South Carolina 29691; and (2) Atkins Library, University of North Carolina, Charlotte, North Carolina 28223.

Q12. Describe in detail any NRC evaluations and the results of such evaluations of the offsite radiological monitoring systems at all other nuclear facilities operated by the applicant. Identify all documents, studies, oral communications and testimony relating to such evaluations.

A12. This information can be obtained from the Public Document Room. See response to Interrogatory 11. The Staff is unaware of any such oral communications.

Q13. What has been the experience with the offsite radiological monitoring systems at all other Duke facilities? Discuss in detail any problems associated with those systems.

A13. This information can be obtained from the Public Document Room. See response to Interrogatory 11.

Q14. What is the accuracy level of the system to be installed at Catawba? Describe in detail how you reached this level of accuracy.

A14. See response to Interrogatory 3.

Q15. Is the information provided by this system immediately ascertainable? If not, how long does it take to obtain the information?

A15. See response to Interrogatory 18.

Q16. Where will the readings of the TLDs take place? In the event of an emergency, can the reading be done at the plant site?

A16. The Duke Power Company Crisis Management Plan describes, in paragraphs C.3., the laboratory facilities available to analyze samples.

Q17. Are there any standards and/or requirements applicable to the reading of the TLDs in a routine situation and in an emergency situation. Identify all such standards and requirements.

A17. The laboratories of the licensee and licensee's contractors will be required to participate in EPA's Environmental Radioactivity Laboratory Intercomparisons Studies Program or equivalent program. (See p. 2 of the BTP (Enclosure A) for more details).

The Emergency Plan provides for field monitoring within the Catawba EPZ to be performed in accordance with Catawba Emergency Procedure HP/0/B/1000/18, "Environmental Surveillance Following a Large Unplanned Release of Gaseous Radioactivity." The procedure describes the field monitoring teams, their equipment, and the procedures to be used in monitoring, sampling, and reducing sample data. TLDs are collected and read in a routine situation per the Radiological Assessment Branch BTP.

Q18. Do you contend that the information provided by this monitoring system will be ascertainable in time to make informed decisions regarding the public health and safety? Explain in detail the bases for your position.

A18. Information from the radiological environmental monitoring program is not immediately available to the reactor operator.* However, it is important to recognize that measurements from the radiological environmental monitoring program are not the primary source of information to be used in making decisions regarding the public health and safety during an accident. The main source of information for making decisions regarding the public health and safety will be obtained from instrumentation that monitors certain plant parameters, and from radiological effluent monitors.

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* The environmental sampling and collection frequencies and the frequencies of analysis under normal operating conditions are given in Table 1 of the BTP.

The results of the radiological environmental monitoring are intended to supplement the results of the radiological effluent monitoring by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and modeling of the environmental exposure pathways.

The primary monitoring of gaseous and liquid radioactive effluents from the vents and discharge points of the plant during normal operations and under some accident conditions is performed by the effluent monitors installed in the plant to measure directly the radioactive content of the effluent streams.

The primary monitoring systems described in the Emergency Plan for Catawba Nuclear Station are under review. The results of the review will be published in the SER for Catawba.

Q19. What is your understanding of the term "real-time monitor?

A19. The Staff's understanding of the term "real-time monitor" is a monitor that both detects radiation continuously and reads out the measurements continuously.

Q20. Was any consideration given to using real-time monitors in place of and/or in addition to TLDs? If so, describe in detail the conclusions you reached. If not, why was no consideration given?

A20. Directed to Applicants.

Q21. Describe in detail the advantages and disadvantages of using real-time monitors in your offsite radiological monitoring system. Identify all studies, documents, oral communications and testimony in support of your position.

A21. Directed to Applicants.

Q22. Do you contend that having continuous, immediate information as would be provided by real-time monitors would not be beneficial in the event of an emergency? Explain in detail your response.

A22. The Staff agrees with the technical evaluation of its contractors (see NUREG/CR-2644), namely, "that the use of a fixed offsite monitoring system to determine the magnitude of an unmonitored release in the presence of a monitored release" would not generally serve a useful function, since "depending on the ratio of the unmonitored release to the monitored release, uncertainties of factors of 25 and 50 would be common." It is unlikely "that a fixed station (16-32 unit) emergency monitoring system would provide sufficiently reliable technical information to be of use in a decision-making process in the event of an emergency situation."

In addition, circumstances whereby the reactor operator would be informed of major leaks by such a monitoring system are not sufficiently probable to justify the expenditure for the system.

Q23. Identify all real-time monitors now available. Describe in detail the detection capabilities, method of transmission, components, meteorological measurement accessories and cost of each.

A23. A list of installed real-time monitoring systems is contained on p. 47 of NUREG/CR-2644 (Enclosure B). See Ch. 4 of NUREG/CR-2644 for information on these systems.

Q24. Identify any problems associated with any of the monitors identified above.

A24. See NUREG/CR-2644.

Q25. Are real-time monitors now being used at any nuclear facilities in the United States? If so, identify the facilities where in use, number of stations at each facility, the distance from each plant, the manufacturer and model of the real-time monitor and the length of time installed.

A25. Information on the nuclear facility, installation date, number of monitoring units, and distance form the plant are contained on p. 47 of NUREG/CR-2644. Information on vendor data is contained in Ch. 4 of NUREG/CR-2644.

Q26. Were the operators of any of these facilities consulted about real-time monitors? If so, describe in detail the questions asked and responses given by those people consulted.

A26. Directed to Applicants.

Q27. Describe in detail the cost effectiveness of real time monitors. Identify all studies, documents, oral communications and testimony consulted and/or relied on in your description.

A27. An analysis of the costs and effectiveness of real-time monitors is contained in NUREG/CR-2644.

Q28. Has the applicant undertaken and/or contracted for any study of the cost effectiveness of real time monitors? Describe in detail any such study.

A28. The Staff is not aware of any study of the cost-effectiveness of real time monitors undertaken by either the Applicants or their contractors. A copy of an NRC study is Enclosure B.

Q29. Is cost the major factor in your decision not to use real time monitors? If not, what is the major factor?

A29. Directed to Applicants.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of DUKE POWER COMPANY, ET AL. (Catawba Nuclear Station, Units 1 and 2)	))))))	Docket Nos. 50-413 50-414

AFFIDAVIT OF JOSEPH JEAN BUZY

I, Joseph Jean Buzy being duly sworn, depose and state that:

1. I am an employee of the U.S. Nuclear Regulatory Commission (NRC). My present position is Reactor Engineer, Licensee Qualification Branch of the Division of Human Factors Safety in the the Office of Nuclear Reactor Regulation. A copy of my professional qualifications is attached.

2. I am duly authorized to respond to interrogatory numbers 1 through 36 on Contention 8 and general interrogatories 1 through 4 of Palmetto Alliance Second Set of Interrogatories and Requests to Produce, and I hereby certify that the statements and opinions given are true and correct to the best of my personal knowledge and belief.

Joseph J. Buzy

Subscribed and Sworn to before me
this 13 day of October, 1982.

Notary Public

My Commission expires: July 1, 1986

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

Joseph Jean Buzy

Professional Qualifications

I am presently assigned as a Nuclear Engineer in the Licensee Qualification Board of the Division of Human Factors Safety within the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission.

I am a graduate of the United States Merchant Marine Academy at Kings Point, New York with a Bachelor of Science in Marine Engineering. I have been employed in the nuclear industry since March 1956.

From 1956 to 1960 I was employed by Bettis Laboratories under contract to the Naval Reactors Program as a operating engineer for the Large Ship Prototype, A1W. I was trained and qualified as Chief Operator on the submarine prototype, S1W, and assisted in training Navy personnel for submarine duty and surface craft personnel for A1W. I later qualified as Chief Operator on A1W and was transfered as test coordinator during startup phase of A1W. I was assinged to the Newport News Shipyard as Bettis Laboratory representative during construction and test of the U.S.S. Enterprise. I assisted in initial startup of two reactor plants on the Enterprise. From 1960 to 1963 I was employed by the Martin Marietta Corporation as a operations/test engineer at the PM-1 plant. The plant was built for the Air Force in Baltimore, Maryland and transported to Sundance, Wyoming. At the site I was qualified and was promoted to Shift Supervisor in charge of an Air Force Crew. I performed in that capacity during the assembly, startup and power demonstration phase. I trained and assisted qualifying a majority of the Air Force personnel. In 1963 I accepted a position as a Nuclear Engineer in the Operator Licensing Branch (OLB) of the AEC. I qualified and was employed as an operator license examiner responsible for developing and administering written and operating tests under 10 CFR Part 55 for all types of reactors licensed under 10 CFR Part 50. I occasionally directed consultant examiners during this period. In 1970 I was appointed Section Leader for Power and Research Reactors. I supervised and trained several Headquarter examiners as well as 6-8 part time consultants. Our group administered examinations at all research reactors, Combustion Engineering, Babcock and Wilcox, General Atomics (HTGRs at Peach Bottom and Ft. St. Vrain) also Fermi I and the SEFOR. In 1978-1979 I was assigned as the OLB Regional Representative in Region II, Atlanta, Georgia. I participated in a Pilot Test Program for Regionalization of OLB functions. I was responsible for all license operator and senior operator license renewals and changes to all requalification program in the Region. I conducted examinations on all types of reactors in the Region. Shortly after Three Mile Island, I was detailed as part of the NRC recovery team at TMI for several weeks. The Pilot Test Program was suspended in the fall of 1979 due to excessive manpower requirements on the OLB staff and I returned to Headquarters as the PWR (Westinghouse) section leader. I was employed in this capacity until February 1982 when I was reassigned to the Licensee Qualification Branch (LQB). My responsibilities in LQB include development of training guides, standards and regulations also development of Commission Papers which involve 10 CFR Part 55. I have been recently assigned a reviewer of Licensee training programs.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
DUKE POWER COMPANY, ET AL.	)	Docket Nos. 50-413
	)	50-414
(Catawba Nuclear Station,	)	
Units 1 & 2)	)	

AFFIDAVIT OF EDWARD F. BRANAGAN, JR.

I, Edward F. Branagan, Jr., being duly sworn, depose and state that:

1. I am an employee of the U.S. Nuclear Regulatory Commission (NRC). My present position is Health Physicist in the Radiological Assessment Branch, Division of Systems Integration within the Office of Nuclear Reactor Regulation. A copy of my professional qualifications is attached.

2. I am duly authorized to participate in answering Interrogatories 1-9, 11-15, 17-19, 22-25, and 27-28 of Palmetto Alliance Second Set of Interrogatories and Requests to Produce, and I hereby certify that the answers given are true to the best of my knowledge.

Edward F. Branagan, Jr.
Edward F. Branagan, Jr.

Subscribed and sworn to before me
this 14th day of October, 1982

[signature]
Notary Public

My Commission Expires: July 1, 1986

EDWARD F. BRANAGAN, JR.
OFFICE OF NUCLEAR REACTOR REGULATION

PROFESSIONAL QUALIFICATIONS

From April 1979 to the present, I have been employed in the Radiological Assessment Branch in the Office of Nuclear Reactor Regulation of the U. S. Nuclear Regulatory Commission (NRC). As a Health Physicist with the Radiological Assessment Branch, I am responsible for evaluating the environmental radiological impacts resulting from the operation of nuclear power reactors. In particular, I am responsible for evaluating radio-ecological models and health effect models for use in reactor licensing.

In addition to my duties involving the evaluation of radiological impacts from nuclear reactors, my duties in the Radiological Assessment Branch have included the following: (1) I managed and was the principal author of a report entitled "Staff Review of 'Radioecological Assessment of the Wyhl Nuclear Power Plant'" (NUREG-0668); (2) I serve as a technical contact on an NRC contract with Argonne National Laboratory involving development of a computer program to calculate health effects from radiation; (3) I serve as the project manager on an NRC contract with Idaho National Engineering Laboratory involving estimated and measured concentrations of radionuclides in the environment; (4) I serve as the project manager on an NRC contract with Lawrence Livermore Laboratory concerning a literature review of values for parameters in terrestrial radionuclide transport models; and (5) I serve as the project manager on an NRC contract with Oak Ridge National Laboratory concerning a statistical analysis of dose estimates via food pathways.

From 1976 to April 1979, I was employed by the NRC's Office of Nuclear Materials Safety and Safeguards, where I was involved in project management and technical work. I served as the project manager for the NRC in connection with the NRC's estimation of radiation doses from radon-222 and radium-226 releases from uranium mills, in coordination with Oak Ridge National

Laboratory which served as the NRC contractor. As part of my work on NRC's Generic Environmental Impact Statement on Uranium Milling (GEIS), I estimated health effects from uranium mill tailings. Upon publication of the GEIS, I presented a paper entitled "Health Effects of Uranium Mining and Milling for Commercial Nuclear Power" at a Conference on Health Implications of New Energy Technologies.

I received a B.A. in Physics from Catholic University in 1969, a M.A. in Science Teaching from Catholic University in 1970, and a Ph.D. in Radiation Biophysics from Kansas University in 1976. While completing my course work for my Ph.D., I was an instructor of Radiation Technology at Haskell Junior College in Lawrence, Kansas. My doctoral research work was in the area of DNA base damage, and was supported by a U.S. Public Health Service traineeship; my doctoral dissertation was entitled "Nuclear Magnetic Resonance Spectroscopy of Gamma-Irradiated DNA Bases."

I am a member of the Health Physics Society.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of DUKE POWER COMPANY, ET AL. (Catawba Nuclear Station, Units 1 and 2)	)))))))	Docket Nos. 50-413 50-414

AFFIDAVIT OF GERALD E. SIMONDS

I, Gerald E. Simonds, having first been duly sworn, hereby state as follows:

1. I am employed by the Nuclear Regulatory Commission as a Physical Scientist in the Emergency Preparedness Licensing Branch.
2. I received a B.S. in Physics from the University of Detroit in 1952, and a M.S. in Mechanical Engineering from the Florida Institute of Technology in 1972. I joined the NRC in October 1981 as a member of the Emergency Preparedness Licensing Branch. My responsibilities include review of the emergency preparedness plans for nine nuclear power plants, including Catawba. This includes review of both onsite and offsite planning. In addition, I have participated in onsite emergency preparedness appraisals and emergency exercises as a team member of several sites. In this context I have conducted onsite checks of emergency equipment and facilities, notification systems, personnel training and performance, procedures and interfaces with offsite agencies and the training of their personnel.

Since coming with the NRC I have successfully completed the Pressurized Water Reactor Technology Course and the Boiling Water Reactor Technology Course at Chattanooga, Tennessee.I am the NRC Staff reviewer for Emergency Preparedness for the Catawba facility.

3. I am duly authorized to participate in responding to Interrogatories 2, 3, 4, 5, 16, 17 and 18, of Palmetto Alliance Second Set of Interrogatories and Requests to Produce dated September 3, 1982, and I certify that the statements and opinions with respect to emergency planning requirements given in response thereto are true and correct to the best of my personal knowledge.

Gerald E. Simonds

Gerald E. Simonds

Subscribed and sworn to before
me this 14 day of October, 1982

Lois E. Snoots

Notary Public

My Commission Expires: July 1, 1986

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
DUKE POWER COMPANY, ET AL.	)	Docket Nos. 50-413
	)	50-414
(Catawba Nuclear Station,	)	
Units 1 and 2)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of "NRC STAFF MOTION FOR PROTECTIVE ORDER" and "NRC STAFF RESPONSES TO PALMETTO ALLIANCE SECOND SET OF INTERROGATORIES AND REQUESTS TO PRODUCE (PALMETTO CONTENTIONS 8 AND 27)" in the above-captioned proceeding have been served on the following by deposit in the United States mail, first class, or, as indicated by an asterisk, by deposit in the Nuclear Regulatory Commission's internal mail system, this 19th day of October, 1982:

*James L. Kelley, Chairman
Administrative Judge
Atomic Safety and Licensing Board Panel
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Administrative Judge
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George E. Johnson
Counsel for NRC Staff

ENCLOSURE A

Revision 1
November 1979

Branch Technical Position

Background

Regulatory Guide 4.8, Environmental Technical Specifications for Nuclear Power Plants, issued for comment in December 1975, is being revised based on comments received. The Radiological Assessment Branch issued a Branch Position on the radiological portion of the environmental monitoring program in March, 1978. The position was formulated by an NRC working group which considered comments received after the issuance of the Regulatory Guide 4.8. This is Revision 1 of that Branch Position paper. The changes are marked by a vertical line in the right margin. The most significant change is the increase in direct radiation measurement stations.

10 CFR Parts 20 and 50 require that radiological environmental monitoring programs be established to provide data on measurable levels of radiation and radioactive materials in the site environs. In addition, Appendix I to 10 CFR Part 50 requires that the relationship between quantities of radioactive material released in effluents during normal operation, including anticipated operational occurrences, and resultant radiation doses to individuals from principals pathways of exposure be evaluated. These programs should be conducted to verify the effectiveness of in-plant measures used for controlling the release of radioactive materials. Surveillance should be established to identify changes in the use of unrestricted areas (e.g., for agricultrual purposes) to provide a basis for modifications in the monitoring programs for evaluating doses to individuals from principal pathways of exposure. NRC Regulatory Guide 4.1, Rev. 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," provides an acceptable basis for the design of programs to monitor levels of radiation and radioactivity in the station environs.

This position sets forth an example of an acceptable minimum radiological monitoring program. Local site characteristics must be examined to determine if pathways not covered by this guide may significantly contribute to an individual's dose and should be included in the sampling program.

If the results of a determination in the EPA crosscheck program (or equivalent program) are outside the specified control limits, the laboratory shall investigate the cause of the problem and take steps to correct it. The results of this investigation and corrective action shall be included in the annual report.

The requirement for the participation in the EPA crosscheck program, or similar program, is based on the need for independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices as part of the quality assurance program for environmental monitoring in order to demonstrate that the results are reasonably valid.

A census shall be conducted annually during the growing season to determine the location of the nearest milk animal and nearest garden greater than 50 square meters (500 sq. ft.) producing broad leaf vegetation in each of the 16 meteorological sectors within a distance of 8 km (5 miles).[2] For elevated releases as defined in Regulatory Guide 1.111, Rev. 1., the census shall also identify the locations of all milk animals, and gardens greater than 50 square meters producing broad leaf vegetation out to a distance of 5 km. (3 miles) for each radial sector.

If it is learned from this census that the milk animals or gardens are present at a location which yields a calculated thyroid dose greater than those previously sampled, or if the census results in changes in the location used in the radioactive effluent technical specifications for dose calculations, a written report shall be submitted to the Director of Operating Reactors, NRR (with a copy to the Director of the NRC Regional Office) within 30 days identifying the new location (distance and direction). Milk animal or garden locations resulting in higher calculated doses shall be added to the surveillance program as soon as practicable.

The sampling location (excluding the control sample location) having the lowest calculated dose may then be dropped from the surveillance program at the end of the grazing or growing season during which the census was conducted. Any location from which milk can no longer be obtained may be dropped from the surveillance program after notifying the NRC in writing that they are no longer obtainable at that location. The results of the land-use census shall be reported in the annual report.

The census of milk animals and gardens producing broad leaf vegetation is based on the requirement in Appendix I of 10 CFR Part 50 to "Identify changes in the use of unrestricted areas (e.g., for agricultural purposes) to permit modifications in monitoring programs for evaluating doses to individuals from principal pathways of exposure." The consumption of milk from animals grazing on contaminated pasture and of leafy vegetation contaminated by airborne

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[2] Broad leaf vegetation sampling may be performed at the site boundary in a sector with the highest D/Q in lieu of the garden census.

B. Nonroutine Radiological Environmental Operating Reports

"If a confirmed[3] measured radionuclide concentration in an environmental sampling medium averaged over any quarter sampling period exceeds the reporting level given in Table 4, a written report shall be submitted to the Director of the NRC Regional Office (with a copy to the Director, Office of Nuclear Reactor Regulation) within 30 days from the end of the quarter. If it can be demonstrated that the level is not a result of plant effluents (i.e., by comparison with control station or preoperational data) a report need not be submitted, but an explanation shall be given in the annual report. When more than one of the radionuclides in Table 4 are detected in the medium, the reporting level shall have been exceeded if:

$$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (2)}} + \ldots \geq 1$$

If radionuclides other than those in Table 4 are detected and are due from plant effluents, a reporting level is exceeded if the potential annual dose to an individual is equal to or greater than the design objective doses of 10 CFR Part 50, Appendix I. This report shall include an evaluation of any release conditions, environmental factors, or other aspects necessary to explain the anomalous result.

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[3] A confirmatory reanalysis of the original, a duplicate, or a new sample may be desirable, as appropriate. The results of the confirmatory analysis shall be completed at the earliest time consistent with the analysis, but in any case within 30 days.

TABLE 1 (Continued)

Exposure Pathway and/or Sample	Number of Samples[a] and Locations	Sampling and Collection Frequency[a]	Type and Frequency of Analysis
WATERBORNE			
Surface[g]	1 sample upstream 1 sample downstream	Composite sample over one-month period[h,i]	Gamma isotopic analysis monthly. Composite for tritium analyses quarterly
Ground	Samples from 1 or 2 sources only if likely to be affected[j]	Quarterly	Gamma isotopic and tritium analysis quarterly
Drinking	1 sample of each of 1 to 3 of the nearest water supplies could be affected by its discharge 1 sample from a control location	Composite sample over two-week period[i] if I-131 anlysis is performed, monthly composite otherwise	I-131 analysis on each composite when the dose calculated for the consumption of the water is greater than 1 mrem per year.[k] Composite for Gross β and gamma isotopic analyses monthly. Composite for tritium analysis quarterly
Sediment from Shoreline	1 sample from downstream area with existing or potential recreational value	Semiannually	Gamma isotopic analyses semiannually
INGESTION			
Milk	Samples from milking animals in 3 locations within 5 km distant having the highest dose potential. If there are none, then, 1 sample from milking animals in each of 3 areas between 5 to 8 km distant where doses are calculated to be greater than 1 mrem per year[k]	Semimonthly when animals are on pasture, monthly at other times	Gamma isotopic and I-131 analysis semimonthly when animals are on pasture; monthly at other times.

TABLE 1 (Continued)

[a]The number, media, frequency and location of sampling may vary from site to site. It is recognized that, at times, it may not be possible or practical to obtain samples of the media of choice at the most desired location or time. In these instances suitable alternative media and locations may be chosen for the particular pathway in question and submitted for acceptance. Actual locations (distance and direction) from the site shall be provided. Refer to Regulatory Guide 4.1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants."

[b]Particulate sample filters should be analyzed for gross beta 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air or water is greater than ten times the yearly mean of control samples for any medium, gamma isotopic analysis should be performed on the individual samples.

[c]Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

[d]The purpose of this sample is to obtain background information. If it is not practical to establish control locations in accordance with the distance and wind direction criteria, other sites which provide valid background data may be substituted.

[e]Canisters for the collection of radioiodine in air are subject to channeling. These devices should be carefully checked before operation in the field or several should be mounted in series to prevent loss of iodine.

[f]Regulatory Guide 4.13 provides minimum acceptable performance criteria for thermoluminescence dosimetry (TLD) systems used for environmental monitoring. One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a thermoluminescent dosimeter may be considered to be one phosphor and two or more phosphors in a packet may be considered as two or more dosimeters. Film badges should not be used for measuring direct radiation. The 40 stations is not an absolute number. This number may be reduced according to geographical limitations, e.g., at an ocean site, some sectors will be over water so that the number of dosimeters may be reduced accordingly.

[g]The "upstream sample" should be taken at a distance beyond significant influence of the discharge. The "downstream" sample should be taken in an area beyond but near the mixing zone. "Upstream" samples in an estuary must be taken far enough upstream to beyond the plant influence.

[h]Generally, salt water is not sampled except when the receiving water is utilized for recreational activities.

[i]Composite samples should be collected with equipment (or equivalent) which is capable of collecting an aliquot at time intervals which are very short (e.g., hourly) relative to the compositing period (e.g., monthly).

[j]Groundwater samples should be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination.

[k]The dose shall be calculated for the maximum organ and age group, using the methodology contained in Regulatory Guide 1.109, Rev. 1., and the actual parameters particular to the site.

[l]If harvest occurs more than once a year, sampling should be performed during each discrete harvest. If harvest occurs continuously, sampling should be monthly. Attention should be paid to including samples of tuborous and root food products.

TABLE 2

Detection Capabilities for Environmental Sample Analysis[a]

Lower Limit of Detection (LLD)[b]						
Anaysis	Water (pCi/l)	Airborne Particulate or Gas (pCi/m3)	Fish (pCi/kg,wet)	Milk (pCi/l)	Food Products (pCi/kg, wet)	Sediment (pCi/kg, dry)
gross beta	4	1×10^{-2}				
^{3}H	2000					
^{54}Mn	15		130			
^{59}Fe	30		260			
$^{58,60}Co$	15		130			
^{65}Zn	30		260			
^{95}Zr	30					
^{95}Nb	15					
^{131}I	1[c]	7×10^{-2}		1	60	
^{134}Cs	15	5×10^{-2}	130	15	60	150
^{137}Cs	18	6×10^{-2}	150	18	80	180
^{140}Ba	60			60		
^{140}La	15			15		

Note: This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported.

In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background should include the typical contributions of other radionuclides normally present in the samples (e.g., potassium-40 in milk samples). Typical values of E, V, Y and Δt should be used in the calculation.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as a posteriori (after the fact) limit for a particular measurement.*

[c]LLD for drinking water samples.

* For a more complete discussion of the LLD, and other detection limits, see the following:
(1) HASL Procedures Manual, HASL-300 (revised annually).
(2) Currie, L. A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry" Anal. Chem. 40, 586-93 (1968).
(3) Hartwell, J. K., "Detection Limits for Radioisotopic Counting Techniques," Atlantic Richfield Hanford Company Report ARH-2537 (June 22, 1972).

TABLE 4

REPORTING LEVELS FOR NONROUTINE OPERATING REPORTS

Reporting Level (RL)

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m³)	Fish (pCi/Kg,wet)	Milk (pCi/l)	Broad Leaf Vegetation (pCi/Kg, wet)
H-3	2×10^{4}(a)				
Mn-54	1×10^{3}		3×10^{4}		
Fe-59	4×10^{2}		1×10^{4}		
Co-58	1×10^{3}		3×10^{4}		
Co-60	3×10^{2}		1×10^{4}		
Zn-65	3×10^{2}		2×10^{4}		
Zr-Nb-95	4×10^{2}				
I-131	2	0.9		3	1×10^{2}
Cs-134	30	10	1×10^{3}	60	1×10^{3}
Cs-137	50	20	2×10^{3}	70	2×10^{3}
Ba-La-140	2×10^{2}			3×10^{2}	

[a]For drinking water samples. This is 40 CFR Part 141 value.

ENCLOSURE B

NUREG/CR-2644
ENICO-1110

An Assessment of Offsite, Real-Time Dose Measurement Systems for Emergency Situations

Prepared by W. J. Maeck, L. G. Hoffman, B. A. Staples, J. H. Keller

Exxon Nuclear Idaho Co., Inc.

Prepared for
U.S. Nuclear Regulatory Commission

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ABSTRACT

An evaluation is made of the effectiveness of fixed, real-time monitoring systems around nuclear power stations in determining the magnitude of unmonitored releases. The effects of meteorological conditions on the accuracy with which the magnitude of unmonitored releases is determined and the uncertainties inherent in defining these meteorological conditions are discussed. The number and placement of fixed field detectors in a system is discussed, and the data processing equipment required to convert field detector output data into release rate information is described. Cost data relative to the purchase and installation of specific systems are given, as well as the characteristics and information return for a system purchased at an arbitary cost.

SUMMARY

The Nuclear Regulatory Commission has been considering a requirement that each operating commercial nuclear power station be fitted with an offsite real-time emergency monitoring system. Currently, several power stations have installed, or are in the process of installing, monitoring systems of varying degrees of complexity and sophistication.

Prior to deciding whether to require all stations to install an offsite real-time emergency monitoring system, the NRC requested an independent evaluation of the usefullness of such a system and an assessment of the validity of the information obtained from the system. The information provided by this study will be used to aid the NRC in their determination of whether or not to require that fixed offsite real-time emergency monitoring systems be installed at all operating and planned commercial nuclear power stations.

This study addresses several aspects of the offsite real-time emergency monitoring system concept. The primary items receiving attention in this study are:

1. The ability of a fixed real-time monitoring system to detect and quantify monitored and unmonitored releases.

2. The ability of the system to detect and quantify an unmonitored release in the presence of a known release.

3. An assessment of the uncertainties associated with estimating the magnitude of an unmonitored release.

4. The number of stations required to detect a release and the uncertainty associated with the detected value.

5. The availability, cost, and the instrumentation requirements for a system.

An augmented effort of the study was to determine the characteristics and information return that might be obtained from a close-in (0.5 mile) system with capital costs limited to $500,000.

A matrix approach was used in this evaluation in which the three major parameters were, 1) the measurement range of the detector, 2) the accuracy of the final results, and 3) the costs.

The general conclusions from this study are presented below. The uncertainty estimates are based on the use of simple error analyses of the meteorological expressions required to describe plume shapes and atmospheric transport.

1. While a ring of detectors around a nuclear power station can provide the means for monitoring releases; the number of stations required for two detectors to provide information within a factor of 5 of each other can be as large as 50 or more for one installation.

2. The use of short-time (15 min) data from a fixed offsite monitoring system to project downwind dose rates is a complex and highly uncertain process. Based on our study the uncertainty associated with a projected value is at least a factor of 10 or more.

3. The use of a fixed offsite monitoring system to determine the magnitude of an unmonitored release in the presence of a monitored release is highly questionable. Depending on the ratio of the unmonitored release to the monitored release, uncertainties of factors of 25 and 50 are common.

4. Several vendors of monitoring equipment were contacted relative to cost and performance characteristics of the available instrumentation. In addition, we contacted several power stations and state agencies involved in the installation of fixed real-time environmental monitoring systems. While the cost factors

for the instrumentation were relatively fixed, the installation costs were highly variable. Based on this study the cost per monitoring station ranges from $25,000 to $65,000. Depending upon the specific site characteristics the cost for a 32 station system could easily exceed $1,000,000 while only providing data with uncertainties in the range of factors of 10 to 50.

5. The placement of a simple limited ($500,000) detector system in proximity (0.5 mi) to a reactor may not provide reliable information in the case of an emergency for several reasons. Of prime importance is the limited number of stations (8-16) that could be installed and the consequence that a plume might go undetected. A second serious problem, especially in the case of a BWR, is the building shine factor which could give a sufficiently high background signal to negate detection of the plume radiation.

In general, it is highly questionable that a fixed station (16-32 units) emergency monitoring system can provide sufficiently reliable technical information to be of use in a decision-making process in the event of an emergency situation.

This conclusion should not preclude consideration of the installation of such a system. A monitoring system could be used to develop site specific meterological information and could develop improved public relations with the populace. It should be emphasized, however, that the stations should be judiciously placed so as not to convey false information.

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1.0 INTRODUCTION

1.1 Background

It has been recommended that systems of offsite, real-time environmental monitors be installed around nuclear power stations. The premise is that the data obtained from such a system could, when coupled with meteorological data, provide information relative to unmonitored, as well as monitored radioactive effluent releases, and provide the basis for making downwind dose rate projections during an emergency accident situation.

1.2 Objective

The purpose of this study is to evaluate this proposal and to provide information to aid the NRC in determining whether or not to require that a fixed offsite monitoring system be installed at all nuclear power stations.

The primary items considered in this study are:

1) The ability and related accuracy of a fixed real-time monitoring system to detect monitored and unmonitored releases.

2) The ability of a fixed real-time monitoring system and associated calculational methods to detect and quantify the magnitude of an unmonitored release in the presense of a known release.

3) To provide an estimate of the credibility (uncertainty) of the information associated with the estimated value of an unmonitored release.

4) To determine, using calculational methods, the number of fixed stations required to detect a release and to provide an estimate of the uncertainty in the measured dose as a function of the number of stations.

5) To provide cost data relative to the installation, operation, and maintenance of a fixed real-time monitoring system.

6) To determine the characteristics and information return for an 800 m (0.5 mile) (probably onsite) emergency system with capital cost limited to $500,000.

1.3 Evaluation Criteria

The variables to be considered in this evaluation are listed below and shown in a matrix array in Figure 1.

Range of Detector (Assume Background of 10 μR/hr)	a.	(0.1 x background) to 10 R/hr
	b.	(1.0 x background) to 10 R/hr
	c.	(10 x background) to 10 R/hr
	d.	(100 x background) to 10 R/hr
Accuracy of Dose to:	a.	± factor of 2
	b.	± factor of 5
	c.	± factor of 10
	d.	± factor of 50
	e.	± factor of 250
Order of Magnitude Costs for Installed System (Excluding Costs for Detectors)	a.	$ 250,000
	b.	$ 750,000
	c.	$2,000,000

The following assumptions are used throughout the evaluation:

1. The detectors will be available as "off the shelf" items and will have the sensitivity to make the required measurements. Calibration procedures will be available to assure a detector response accurate to ± 25%.

2. The monitoring stations will be located within 3200 m (2 miles) of the plant and the measurements will be averaged on a 15-minute time scale. The costs of the detectors will not be considered; but costs for signal averaging, transmission, and correction for background will be included.

3. Meteorological information requirements will be those required to satisfy NUREG-0654, Regulatory Guide 1.97 and the Proposed Revision to the Regulatory Guide 1.23.

4. Computerized analysis of the dectector and meteorological input will use in-house or "off the shelf" hardware and software to provide accurate and intelligible output for use in control room decisions. For offsite, real-time monitoring system output to be intelligible, the information presented to the operator in the control room must describe in real time the significant features of the release, such as dose distribution and contours within two miles and characterization of the source. In addition, the computer analysis must provide for ownwind dose prediction capability beyond two miles.

5. The source term to be evaluated will be limited to mixtures of radionuclides which are nondepositing, i.e., only the noble gases without radioactive daughters.

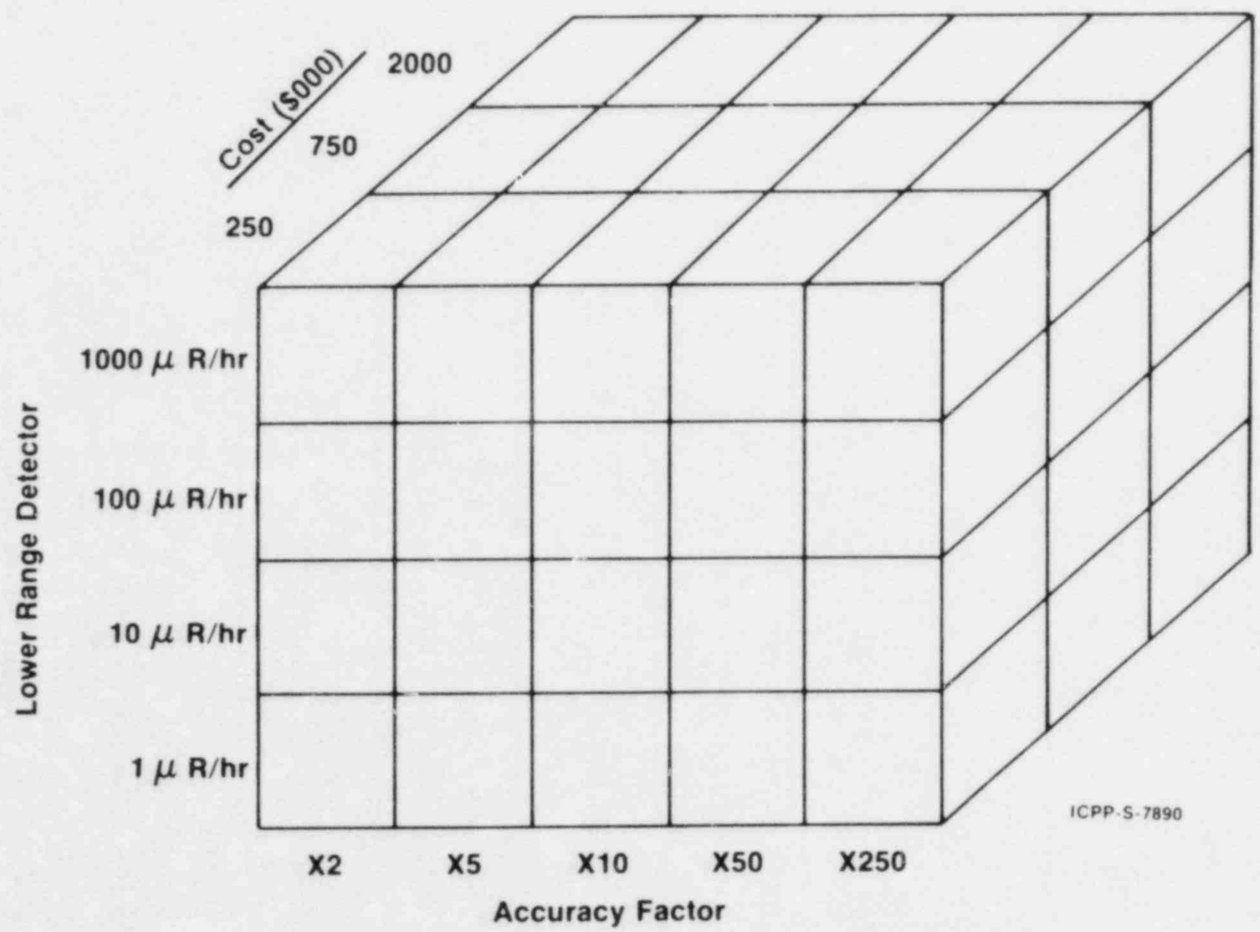

Figure 1. Matrix Parameters

2.0 QUANTIFICATION AND ASSESSMENT OF THE UNCERTAINTIES ASSOCIATED WITH THE MEASUREMENT OF AN UNMONITORED RELEASE

To provide an evaluation of the accuracy which might be obtained from a fixed offsite real-time monitoring system we used simple statistical methods of error analysis. Of particular concern was the quality and credibility of the values obtained for an unmonitored release in the presence of a known release.

The model used for this evaluation is shown in Figure 2, in which

D_B is dose related to background,
R_1 is the known or monitored release,
R_2 is the unknown release,
D_1 is the dose related to R_1,
D_2 is the dose related to R_2, and
D_T is the total dose measured by the receptor.

Thus, the total dose, D_T, is the sum of D_1, D_2 and D_B which are in some form proportional to R_1 and R_2.

$$D_T = D_1 + D_2 + D_B \qquad (1)$$

$$\text{where } D_1 \propto R_1$$
$$\text{and } D_2 \propto R_2$$

To obtain a value for the unmonitored release in the presence of a known release, the following procedure is used. First, the measured value for R_1 is converted to a dose, D_1, using the equations given in Section 2.1. Second, the calculated value D_1 is subtracted from the measured value D_T to give a value for D_2. Third, the value D_2 is then converted to a value for R_2, using the same equations to obtain D_1. It is assumed that D_B is small in comparison to D_1 and D_2 and can therefore be ignored.

The following is a discussion of the errors associated with each step in the calculational procedure and an assessment of the uncertainty in the value of R_2.

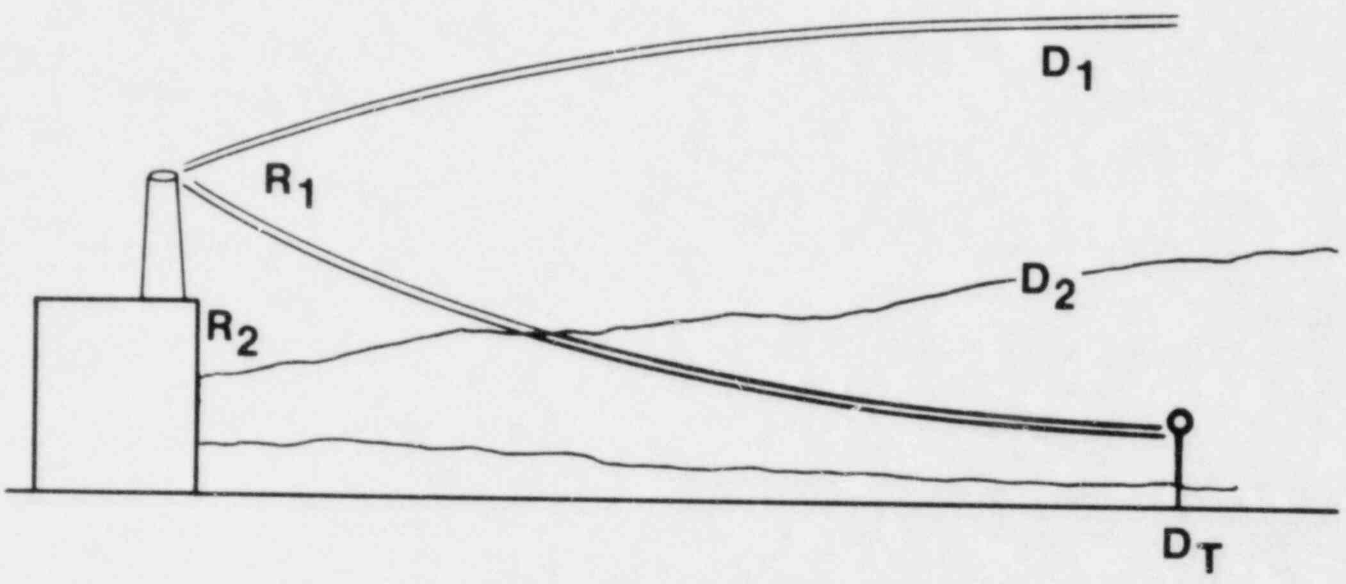

Figure 2. Model to Evaluate the Estimate of an Unmonitored Release in the Presence of a Known Release

2.1 Prediction of Downwind Atmospheric Concentration Values

The first calculational step involved in the model given in Figure 2 is conversion of the measured release R_1 to a dose D_1. The most commonly used method for calculating the exposure to a receptor involves converting the known release value to an atmospheric concentration value at some downwind distance and then integrating the concentration over the volume of the plume. The exposure is then proportional to the product of the integrated concentration and the decay energy of the radionuclides present in the plume, expressed as an exposure rate per unit release (R/hr)/(Ci/s) at 1 m/s wind speed. The detector response calculated in this study is in exposure rate. However, in the remainder of this report the authors equate exposure rate and "dose rate" as is common practice.

The atmospheric concentration value at some downwind distance is usually calculated using the Gaussian plume equation. This is an empirical diffusion formula which assumes constant wind speed, no wind shear, and flat topography. The equation for a continuous point source release is:

$$\chi(x,y,z) = \frac{QG(z)}{2\pi\sigma_y\sigma_z\bar{\mu}} \exp\left(-\frac{1}{2}(y/\sigma_y)^2\right) \qquad (2)$$

where:

- χ = atmospheric concentration at a calculated point (x,y,z) for a release point h meters above the ground, Ci/m^3
- Q = source term (release rate), Ci/seconds
- $G(z) = \exp -\frac{1}{2}((z-h)/\sigma_z)^2 + \exp -\frac{1}{2}((z+h)/\sigma_z)^2$
- σ_y = horizontal atmospheric diffusion parameter, m
- σ_z = vertical atmospheric diffusion parameter, m
- $\bar{\mu}$ = average wind speed, m/sec
- y = cross wind distance, m
- h = release height, m
- x,y,z = coordinates of the point where the concentration is calculated

In this relationship the most critical terms are the values for σ_y and σ_z. Both of these terms carry a different value for each class of atmospheric stability and downwind distance. Unfortunately, the values for σ_y and σ_z are not explicitly mathematically defined and as such must be determined empirically. A number of different field experiments have been conducted to determine σ_y and σ_z as functions of atmospheric stability conditions (weather class) and downwind distances.

Currently, the most widely used data sets for σ_y and σ_z are those based on the Pasquill-Gifford[1] model for atmospheric diffusion. Several methods have been used to establish the atmospheric stability class which must be determined prior to obtaining the values for σ_y and σ_z. One general classifying scheme is based on isolation, cloud cover, and wind speed. The standard deviation of the horizontal wind direction is also used to establish the stability class. Another method, recommended by the NRC[2] (Reg. Guide 1.23) uses the temperature gradient between 10 and 60 m (or the release height) above the ground to determine the stability classification. None of these methods are without uncertainties, and in many cases the selection of the proper atmospheric stability class may be in error by one or more classes.

Assuming an error of one stability class in the assignment process (i.e. - assigning class D for a real class E conditions), we determined the error which would be introduced in the value for χ based on the Pasquill-Gifford curves[3] for adjacent atmospheric stability classes. The effect on the value for χ at distances of 1000 m and 3000 m for release heights of 10 m and 100 m is given in Tables I and II, respectively. For a near ground-level release, the error in the predicted groundlevel average concentration could range from a factor of 2 to 10 for a one unit misassignment of the stability class. For a 100 m release the errors can be much larger.

To establish the frequency with which the stability class may be in question, four months of meteorological data for an inland nuclear power station were evaluated. For this station, both the standard deviation of the horizontal wind direction and the temperature gradient data were available on an hourly basis. An analysis of these data indicates that the assigned stability class based on these two methods differed by one class ~43% of the time, and by two classes, up to 25% of the time. The results shown in Table III indicate that the stability class assignment based on the two methods differed about 60% of the time. Thus, the downwind ground-concentration value could be in error by a factor of 5 about half of the time just from this source.

Table I. ERRORS IN X (GROUND-LEVEL AVERAGE CONCENTRATION) FOR A ONE UNIT ASSIGNMENT ERROR IN STABILITY CLASS

Release Height 10 m

True Class	Assigned Class	Error Factors D = 1000 m Over-predict	Error Factors D = 1000 m Under-predict	Error Factors D = 3000 m Over-predict	Error Factors D = 3000 m Under-predict
A	B	5		10	
B	A		5		10
B	C	3		4	
C	B		3		4
C	D	3		4	
D	C		3		4
D	E	2		2	
E	D		2		2
E	F	2		2	
F	E		2		2

Example: If the true stability class is C and the assigned class is D, the Gaussian plume model using Pasquill-Gifford diffusion values for class D at 3000 m over-predicts the ground-level average concentration by a factor of 4.

Table II. ERRORS IN χ (GROUND-LEVEL AVERAGE CONCENTRATION) FOR A ONE UNIT ASSIGNMENT ERROR IN STABILITY CLASS

Release Height, 100 m

True Class	Assigned Class	Error Factors D = 1000 m Over-predict	Error Factors D = 1000 m Under-predict	Error Factors D = 3000 m Over-predict	Error Factors D = 3000 m Under-predict
A	B	5		30	
B	A		5		30
B	C	1		6	
C	B		1		6
C	D		12	1	
D	C	12			1
D	E		15		2
E	D	15		2	
E	F		800		33
F	E	800		33	

Table III. VARIABILITY IN STABILITY CLASS ASSIGNMENT BASED ON TWO DIFFERENT MEASUREMENT METHODS

Date	No. Observation	One Class Difference	Two Class Difference
June-1974	640[a]	274 (43%)[b]	39 (6%)
July-1974	430	186 (43%)	113 (26%)
Aug.-1974	613	262 (43%)	76 (12%)
Sept.-1974	661	281 (43%)	152 (23%)

a) Number of hourly observations for which both wind variability and temperature differential data were available.

b) Percentage of the time that the stability class assignments were different.

At this point it might be well to recognize that the Gaussian plume equation only provides concentration estimates and not dose estimates. In general, the uncertainties in the dose values are not as variable as the ground-level concentration values, because the cloud gamma dose is an integrated value as opposed to a point concentration value. This fact, however, should not preclude consideration of the uncertainties in concentration values predicted by the Gaussian plume equation because the ground-level concentration values are more important with respect to the beta dose factor, the inhalation dose factor, and the ground-level concentration value for radioiodine, which may be the dominant factor in an accident case. The uncertainties associated only with the dose values will be treated in detail later in this Section.

Another item which must be considered regarding the uncertainties associated with the Gaussian plume equation and ground-level concentration values, is the validity of the primary diffusion data based on the Pasquill scheme. The basic Pasquill diffusion data were derived from tracer experiments which involved a ground-level release over very flat terrain with sampling periods of a few minutes at distances of up to about 1 km. Unfortunately through time and widespread usage, the original nature of the experiment seems to have been forgotten by many users of the data, and the original results have been extrapolated to include elevated release points (up to 100 m) and to distances of up to 100 km. Pasquill diffusion parameters are primarily applicable to short term releases at or near ground-level over relatively short distances (1 km) and quite flat terrain.

Because of the restrictive nature of the Pasquill scheme, more recent experiments have been conducted to attempt to better quantify the diffusion parameters for the more realistic cases (i.e. hills, rough terrain, forests, metropolitan areas, and elevated releases). Some examples are given in References 4, 5, and 6. Vogt[7] and Brenk[8] have reviewed these experiments in some detail and compared the diffusion parameters derived from these experiments to each other and to Pasquill. In some cases the downwind concentration values may differ by factors of 10 to 1000, depending upon the stability class involved.

Figures 3, 4 and 5 taken from Brenk[8] give comparisons of the short-term diffusion factors for the various experimental results for stability classes A, D, and F as a function of distance, for a release height of 100 m. For class A, unstable diffusion, the data are in good agreement. However, with increasing atmospheric stability, significant differences are evident (Figures 4, 5). For class D stability at a distance of 1000 m, the difference between the Pasquill diffusion factor and the majority of the other systems is a factor of 10 to 15. At 3000 m the difference is about a factor of 5.

For class F stability there is little agreement in the diffusion factors for the various systems and differences of a factor of 100 to 1000 are common.

These data are presented not to dwell on the large differences between the various systems, but rather to emphasize the need for selecting the most applicable system for a given site. Ideally, the preferred situation is to develop site specific data. Unfortunately, experiments of this type are difficult and expensive to conduct. Brief descriptions

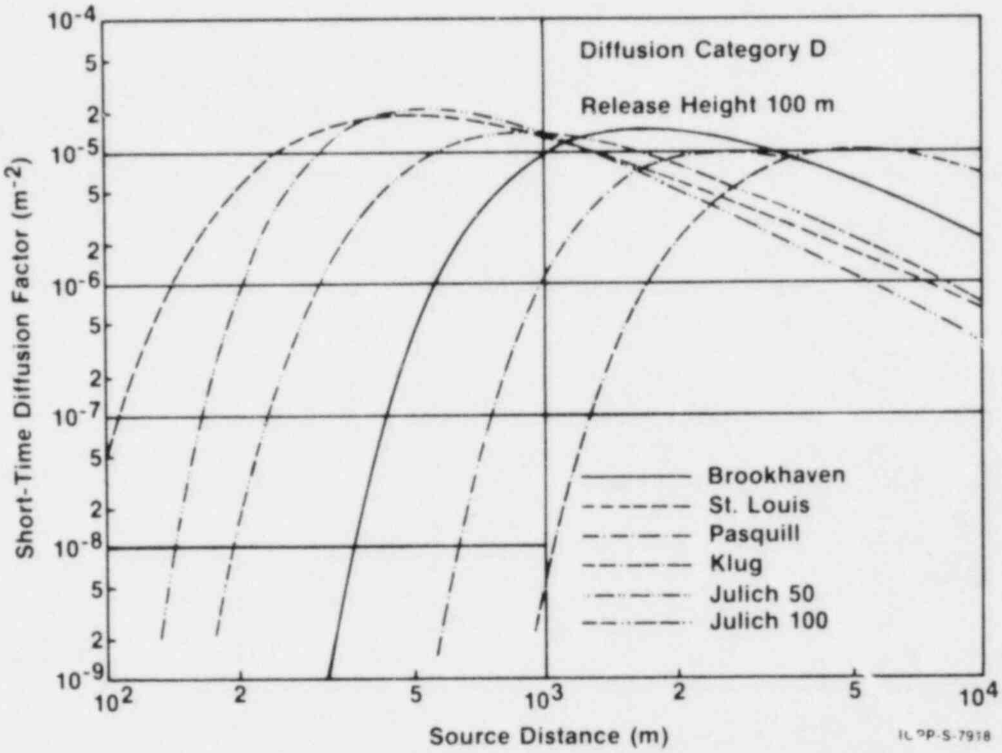

Figure 3. Comparison of Short-Term Diffusion Factors (Stability Class A) Depicted for 6 Different Diffusion Parameter Systems (From Brenk, ref. 8)

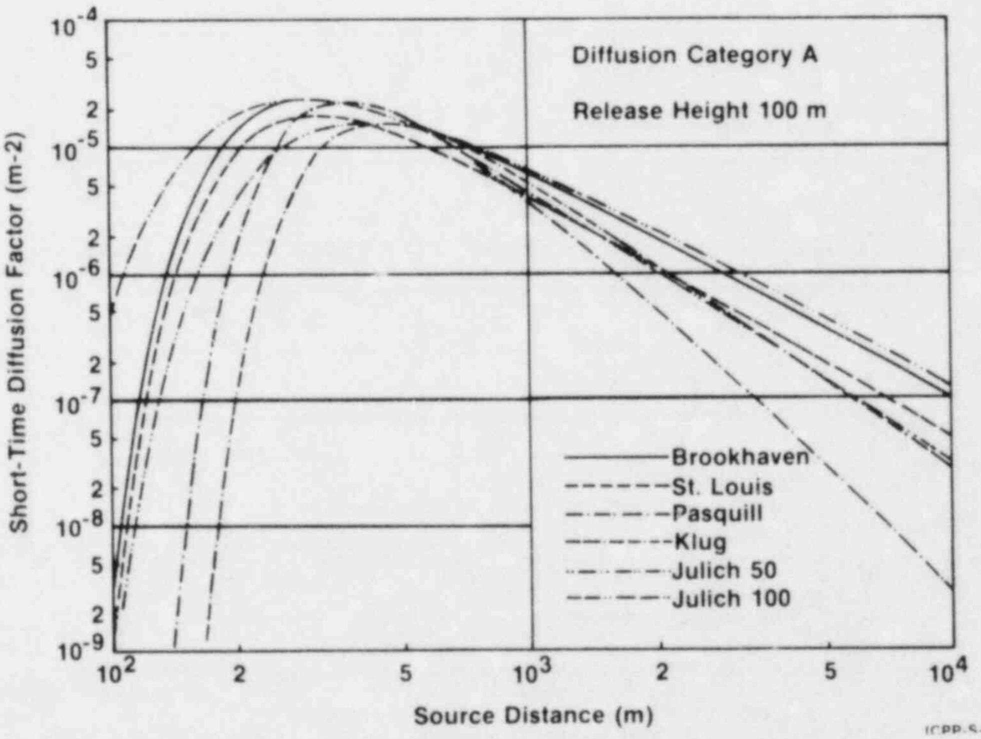

Figure 4. Comparison of Short-Term Diffusion Factors (Stability Class D) Depicted for 6 Different Diffusion Parameter Systems (From Brenk, ref. 8)

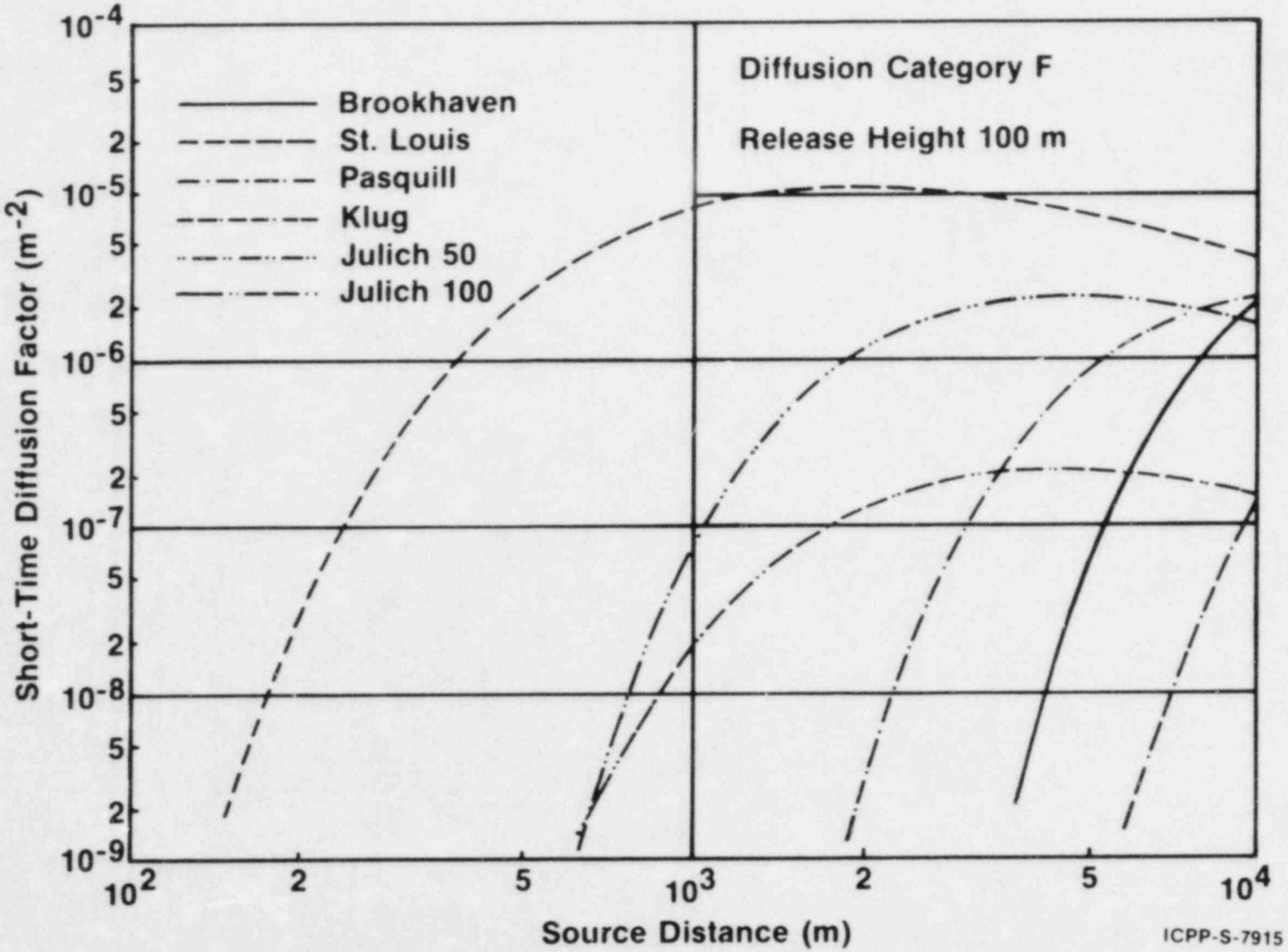

Figure 5. Comparison of Short-Term Diffusion Factors (Stability Class F) Depicted for 6 Different Diffusion Parameter Systems (From Brenk, ref. 8)

and the result and data obtained from some recent experimental programs are given in Appendix A. Included are reviews of the Savannah River ^{85}Kr experiment,[9] the ORNL assessment of the Hanford experiment[10], excerpts from a Workshop on the Evaluation of Models Used for the Environmental Assessment of Radionuclide Releases,[11] and results of a survey of programs used for radiological dose computations.[12]

Presently, it is virtually impossible to give a definitive estimate of the overall uncertainty to be associated with the prediction of downwind concentration values, especially for data related to short time periods. However, based on our study and those of others[9,10,11,12] we believe that a predicted value which may vary by a factor of 10 to 25 from the true downwind concentration is not unreasonable. Even this estimate may be low if site specific diffusion parameters are not available.

2.2 Prediction of Downwind Atmospheric Dose Values

The calculation of the cloud gamma exposure from a plume is a two-step process. First, the radionuclide concentration of the plume is calculated using the Gaussian plume dispersion equation given in Section 2.1 (Eq. 2). Second, the total cloud gamma exposure rate at the detector is calculated by using a point source approximation and integrating over the source distribution (i.e. the volume of the plume). Both components of the exposure rate calculation have been incorporated into a code developed by Science Application, Inc.,[13] which was used in this study to establish detector response values.

The assumptions and parameters used to calculate the cloud gamma values presented in this report are given below.

1. The Gaussian plume equation given in Section 2.1 (Eq. 2) was used to establish the plume dispersion and downwind concentration values. The values used for σ_y and σ_z are given in Appendix-II.

2. The cloud gamma exposure rate at a receptor was obtained by using a point source approximation and integrating over the volume of the plume. This involved an extensive numerical summation of small volume elements. Although this is a lengthy process, we believe the results are more representative than those obtained from the use of infinite or semi-infinite cloud approximations. The following is the methodology used to calculate the cloud gamma exposure rate to a receptor.

$$\text{exposure rate} \quad D\left(\frac{R}{h}\right) = C\,\frac{\mu a}{\rho}\,EB(\mu R)\,\Gamma \qquad (3)$$

where

$$C = 6.87 \times 10^{-5} \quad \frac{R\text{-}g\text{-}s}{MeV\text{-}h}$$

$\frac{\mu a}{\rho}$ = mass absorption coefficient for air at energy E (m^2/g)

E = energy per photon MeV/photon

$B(\mu R)$ = buildup factor

Γ = photon flux $\left(\frac{photons}{m^2\text{-}s}\right)$

$$\text{photon flux } \Gamma \left(\frac{photons}{m^2\text{-}s}\right) = \frac{s}{4\pi r^2}\,e^{-\mu r} \qquad (4)$$

where

s = photon emission rate (photons/s)

r = distance from source (m)

μ = total linear attenuation coefficient for air (m^{-1})

The photon emission rate, s, was determined by assuming a small volume, dV, at concentration χ as follows:

$$S \text{ (photons/s)} = 3.7 \times 10^{10} \chi I_{\kappa} dV \quad (5)$$

where

3.7×10^{10} = the the number of disintegrations per second per curie

χ = radionuclide concentration in the small volume element $dV(Ci/m^3)$

I_{κ} = number of photons of energy E per disintegration

dV = volume element considered (m^3)

Combining equations 4 and 5

$$\dot{D} \left(\frac{R}{h}\right) = \frac{2.5\ 4 \times 10^6}{4\pi r^2} \frac{\mu a}{\rho} E\ I_{\kappa}\ \chi e^{-\mu r} B(\mu r)\ dV \quad (6)$$

Equation 6 is the contribution to the exposure rate at the detector due to the small volume element dV. The total exposure rate was obtained by integration over the volume of the plume. When using the code, $\chi\bar{\mu}/Q$ was used in equation 6 instead of χ to subsequently give results in terms of $\dot{D}\,\bar{\mu}/Q$ or exposure rate per unit release rate (R/h)/(Ci/s) at 1 meter per second wind speed.

Several calculations were made to evaluate the dose rate to a receptor as a function of stability class, distance, and release height. The dose rate as a function of distance for several stability classes for a ground level release is shown in Figure 6. At a distance of 3200 m (2 miles), the centerline dose can vary by at least four orders of magnitude over the extreme stability class range of A to F. The uncertainty in the dose as a function of adjacent stability classes can also be estimated from Figure 6. For example, at a distance of two miles the difference in the maximum centerline dose between stability class B and C is approximately 8, and between stability class C and D, approximately 3. These values are for an average gamma ray energy of $\sim$80 keV(^{133}Xe). The differences are only slightly less for an average energy of 250 keV.

The effect of the release height on the dose rate as a function of distance for three different stability classes is shown in Figure 7. For the worst case, class F, the dose rate at short distances (500-1000 m) can vary a factor of 6-12 between a release height of 0 to 100 m. This difference decreases as a function of distance. At 3200 m the difference is approximately 2.5.

In the discussions presented up to this point, we have assumed that the centerline of the plume has passed directly over the receptor, thereby giving the maximum dose value. The probability of this happening is quite remote. The number of detectors and their placement required to give accurate dose readings will be discussed in detail in Section 3.

Based on the calculated data given in Figures 6 and 7 and the problems presented with respect to an accurate assessment of the prevailing weather class and to a knowledge of the location of the source term, it is our opinion that the calculated downwind dose value must carry an associated uncertainty of at least a factor of 10 or more.

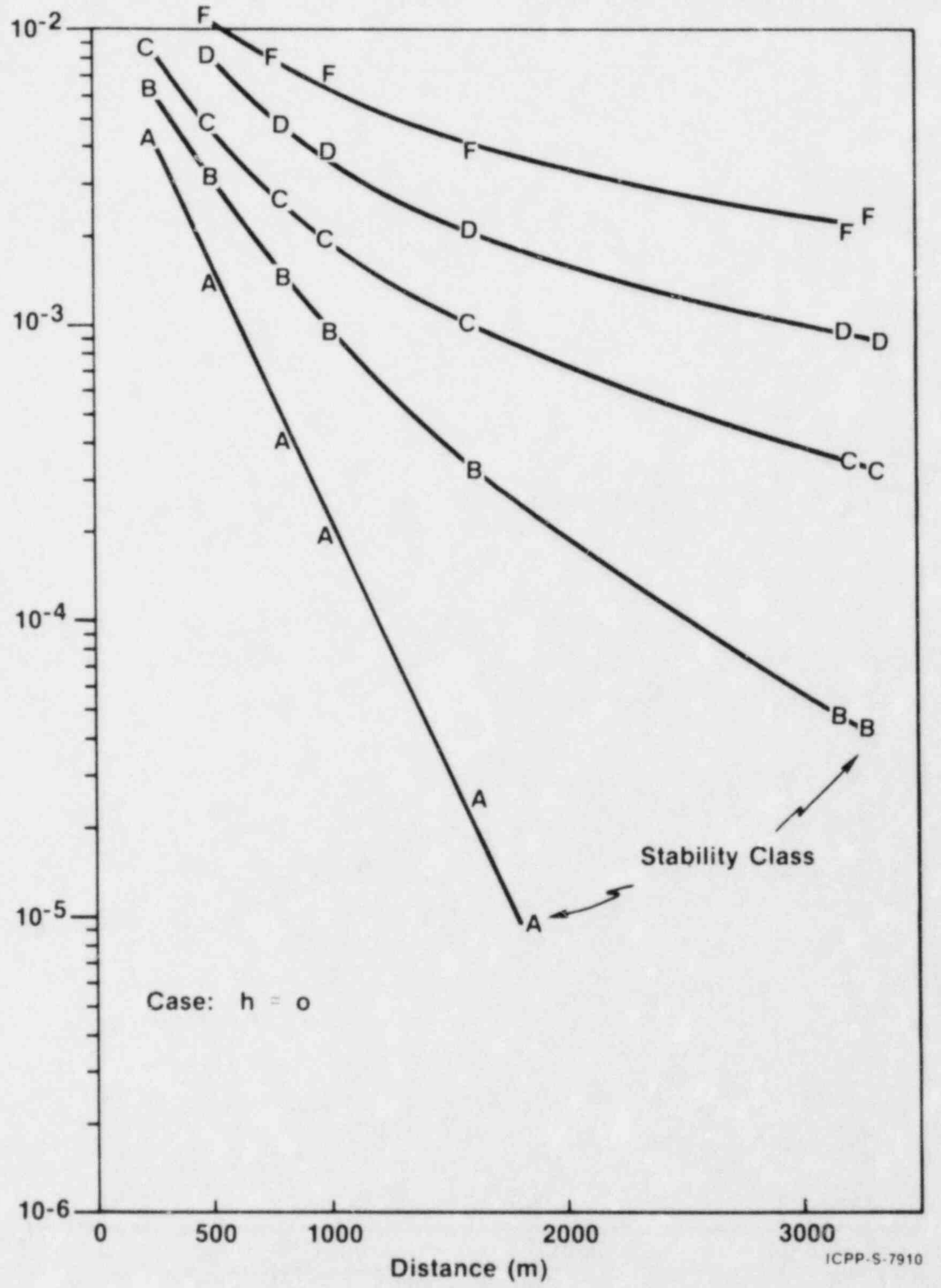

Figure 6. Projected Center Line Dose as a Function of Stability Class and Distance For a Ground Level Release

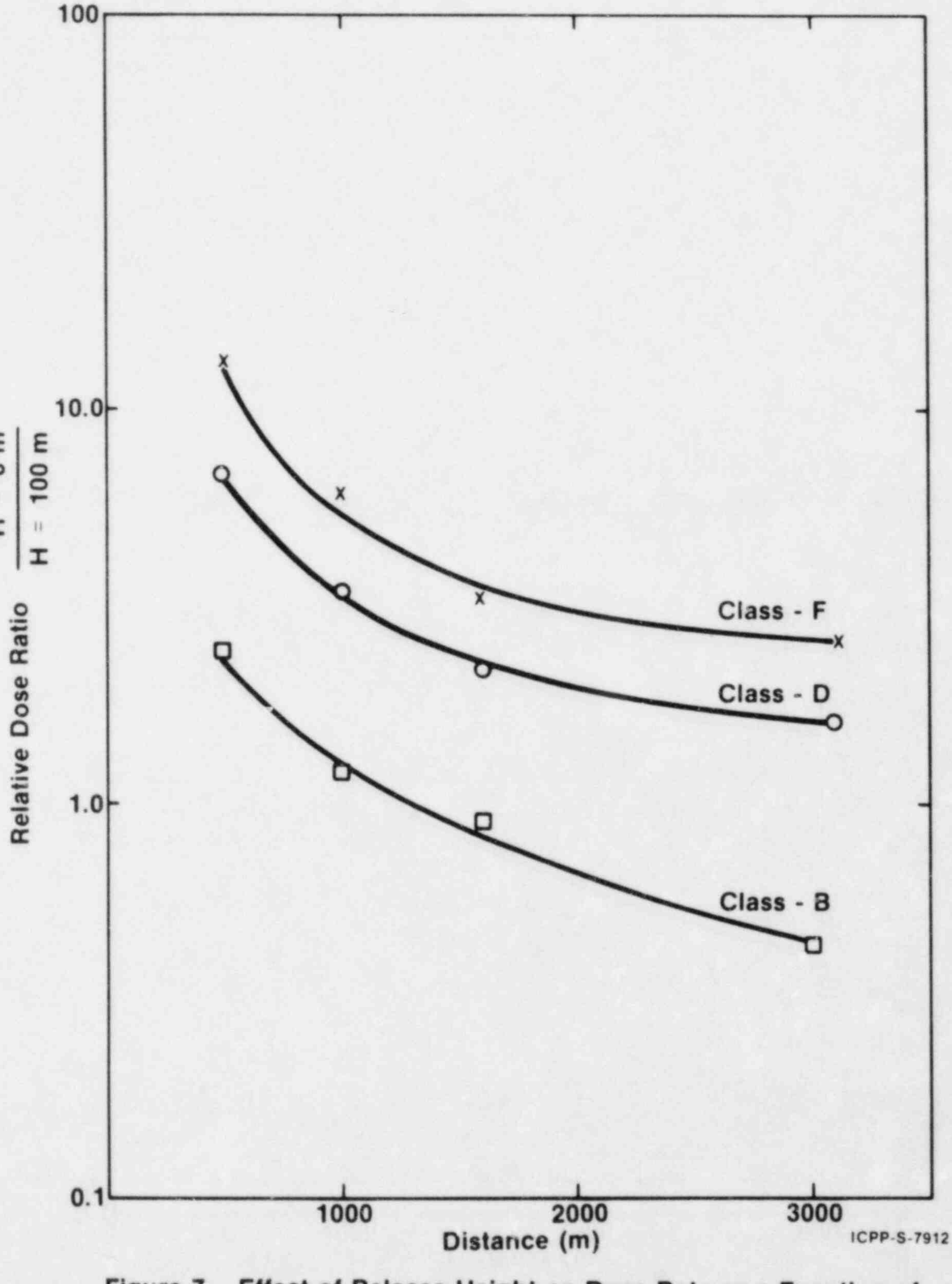

Figure 7. Effect of Release Height on Dose Rate as a Function of Distance for Stability Class B, D, and F

2.3 Uncertainties Associated with the Quantification of an Unmonitored Release

The uncertainties and range of values associated with quantifying the magnitude of an unmonitored release (R_2) in the presence of a known release (R_1) were calculated based on the model given in Figure 2 and the relationship,

$$D_T = D_1 + D_2$$

$$\text{where } D_1 \propto R_1\text{, and}$$
$$D_2 \propto R_2.$$

The calculation of the expected error in R_2 assumed the following conditions:

1. | | | | |
   |---|---|---|---|
   | R_2(constant) | 1 | 1 | 1 |
   | R_1(variable) | 10 | 1 | 0.1 |

2. The uncertainties assigned to D_1 were:

± factor of 2	(200%)
± factor of 5	(500%)
± factor of 10	(1000%)
± factor of 25	(2500%)

3. The same uncertainties were assigned to D_2; however, in many cases the uncertainty associated with D_2 may be larger than D_1 because the height of the release is probably unknown.

4. No significant error was assumed in the measured dose, D_T.

5. The background contribution is small. If the background is significant with respect to the measured D_T value the resultant error will increase.

The results of the error analysis are given graphically in Figure 8 and listed in Table IV. In Figure 8, the range in the values for R_2 as a function of the ratio R_1/R_2 are given for a family of uncertainty assignments for D_1 and D_2. From this simple error analysis it is concluded that uncertainties of factors of 10 to 25 are possible for the calculated value for the unmonitored release, especially when the magnitude of the unmonitored release is equal to or smaller than the known release. For the case where the unmonitored release is large with respect to the known release the uncertainty in the unmonitored release will approach the error associated with the values for D_1 and D_2.

For example, in the case where the known release and the unmonitored release, R_1 and R_2 respectively, are of equal magnitude (in this case, 1) and the assumed uncertainty in the calculated values for D_1 and D_2 is a factor of 10, the value for R_2 can have a range of 0 to 19 for a true value of 1. For the case where the unmonitored release is 10 times larger than the known release and the uncertainty in D_1 and D_2 is a factor of 10, the value of R_2 can have a range of 0 to 11 for a true value of 1. For the case where R_2 is only one-tenth of R_1 the uncertainty in the value 1 for R_2 increases dramatically, having a range of 0 to 100 for an uncertainty of a factor of 10 in D_1 and D_2.

This error analysis only presents the range of relative values to be associated with an unmonitored release having an assigned value of 1. It does not provide an estimate of the true value of the unmonitored value. The accuracy of the true value for the unmonitored release depends on the location of the plume relative to the detector. If the plume centerline is several degrees removed from the detector, the measured value for D_T could be low by a factor of 2 to 10 depending on the proximity of the plume to the detector. This effect is discussed in detail in Section 3.

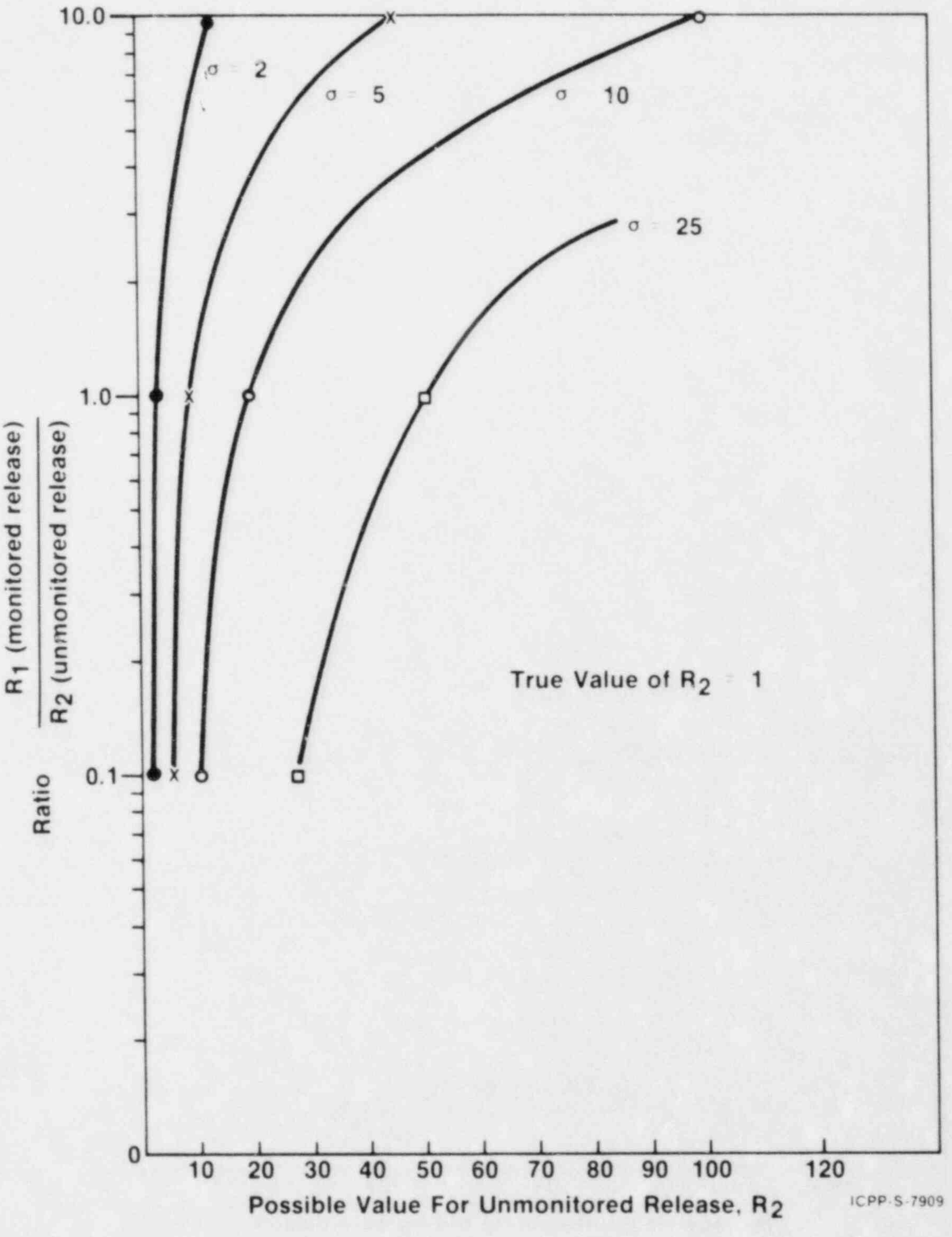

Figure 8. Uncertainty in Calculated Values of an Unmonitored Release in the Presence of a Monitored Release

Table IV RANGE OF UNCERTAINTIES WHICH CAN BE ASSOCIATED WITH AN UNMONITORED RELEASE HAVING A TRUE VALUE = 1.

CASE: 1	UNCERTAINTY D_1, D_2	RANGE IN CALCULATED VALUE OF R_2
R_1 = 10	200%	12 to -4.5
R_2 = 1	500%	45 to -7.8
R_T = 11	1000%	100 to -8.9
	2500%	265 to -9.6
CASE: 2		
R_1 = 1	200%	3 to 0
R_2 = 1	500%	9 to -0.6
R_T = 2	1000%	19 to -0.8
	2500%	49 to -0.9
CASE: 3		
R_1 = 0.1	200%	2.1 to 0.5
R_2 = 1	500%	5.4 to 0.1
R_T = 1.1	1000%	10.9 to 0.01
	2500%	27.4 to -0.1

3.0 DETECTOR PLACEMENT AND REQUIREMENTS

3.1 Detector Placement and Response Functions

The response functions and requirements for a ring of detectors were determined by calculating the dose rate from a plume at various distances from the plume centerline. Figure 9 gives the dose rates at 1600 m for three different stability classes (A, C, and F) as a function of distance from the plume centerline for a ground level release of 1 Ci/s. The curves given in Figure 9 describe one-half of the plume shape; from the centerline to one edge. The plume shapes and dose rates were calculated for 80 keV gamma rays (^{133}Xe) using the equation and input factors given in Section 2.2.

The number of detectors required for two adjacent detectors to give responses within factors of 2, 3, 5, and 10 of each other was determined based on the plume shape (i.e., the width of the plume). For the plume shape corresponding to stability class C (Fig. 9), the lateral distance from the plume centerline which gives a signal equal to one-half of the maximum was determined to be ~7.8 degrees. Dividing a 360 degree circle by this value gives a value of 46, which is the number of detectors required for two adjacent detectors to give a response within a factor of two of each other. The same process was used to establish the number of detectors required to give readings within factors of 3, 5, and 10 of each other for each stability class. In all cases, it was assumed that the plume centerline was directly over one detector. This is the worst case situation.

Figure 10 shows the number of detectors at 1600 m required to give responses agreeing within 200%, 300%, and 500% as a function of stability class. These results are for straight line meterology, a release height of 100 m, and an average gamma ray energy of 80 keV. For class F weather (the worst case) about 85 detectors are required for two adjacent detectors to give signals within a factor of two of each other. For a ground-level release, approximately 100 detectors would be required for a factor of two agreement. Even for class B weather and a release height of 100 m, about 36 detectors would be required for agreement within a factor of two.

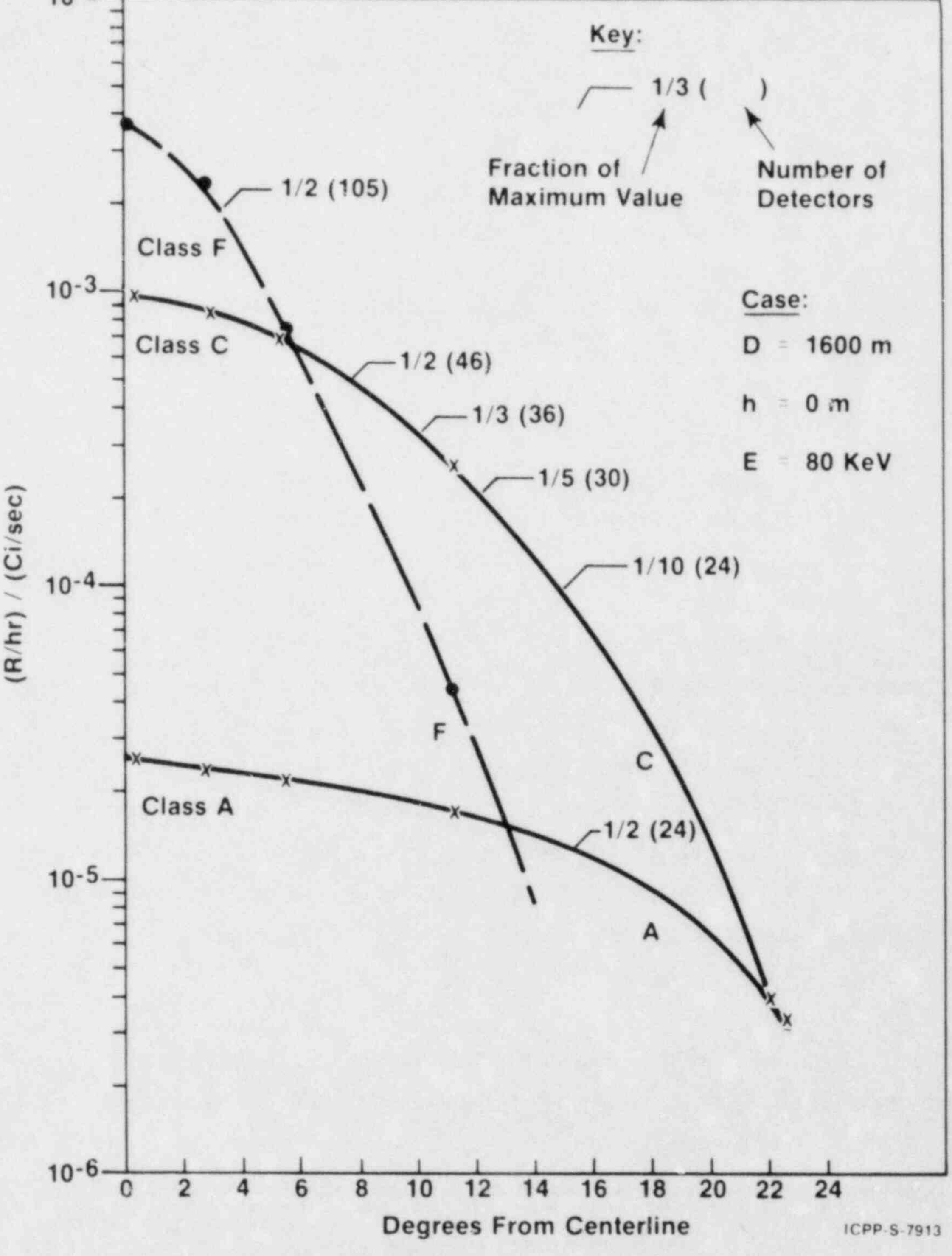

Figure 9. Plume Shape Analysis for Determining Detector Requirements

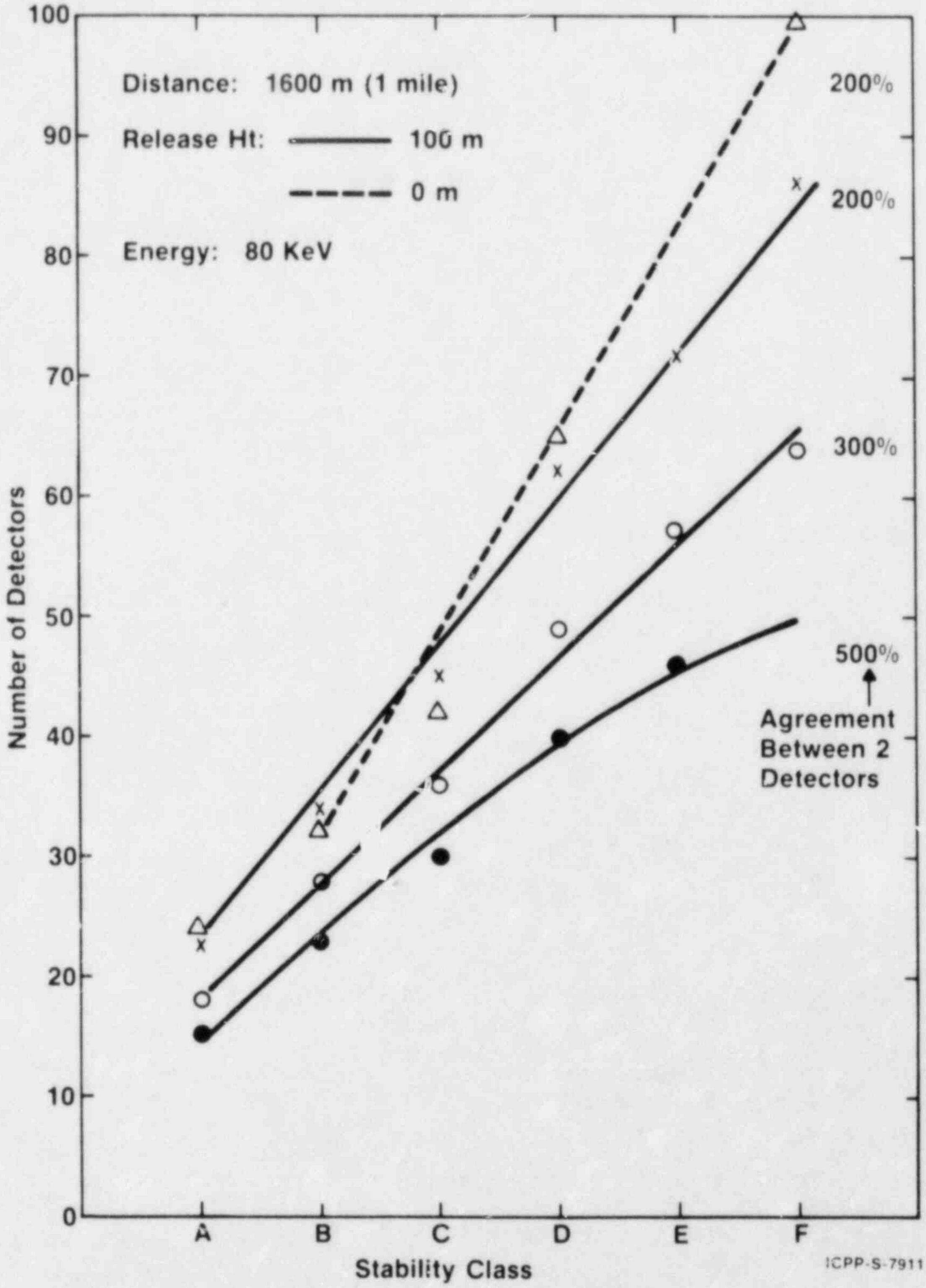

Figure 10. Number of Detectors Required at 1600 m to give Response within 200, 300, and 500%

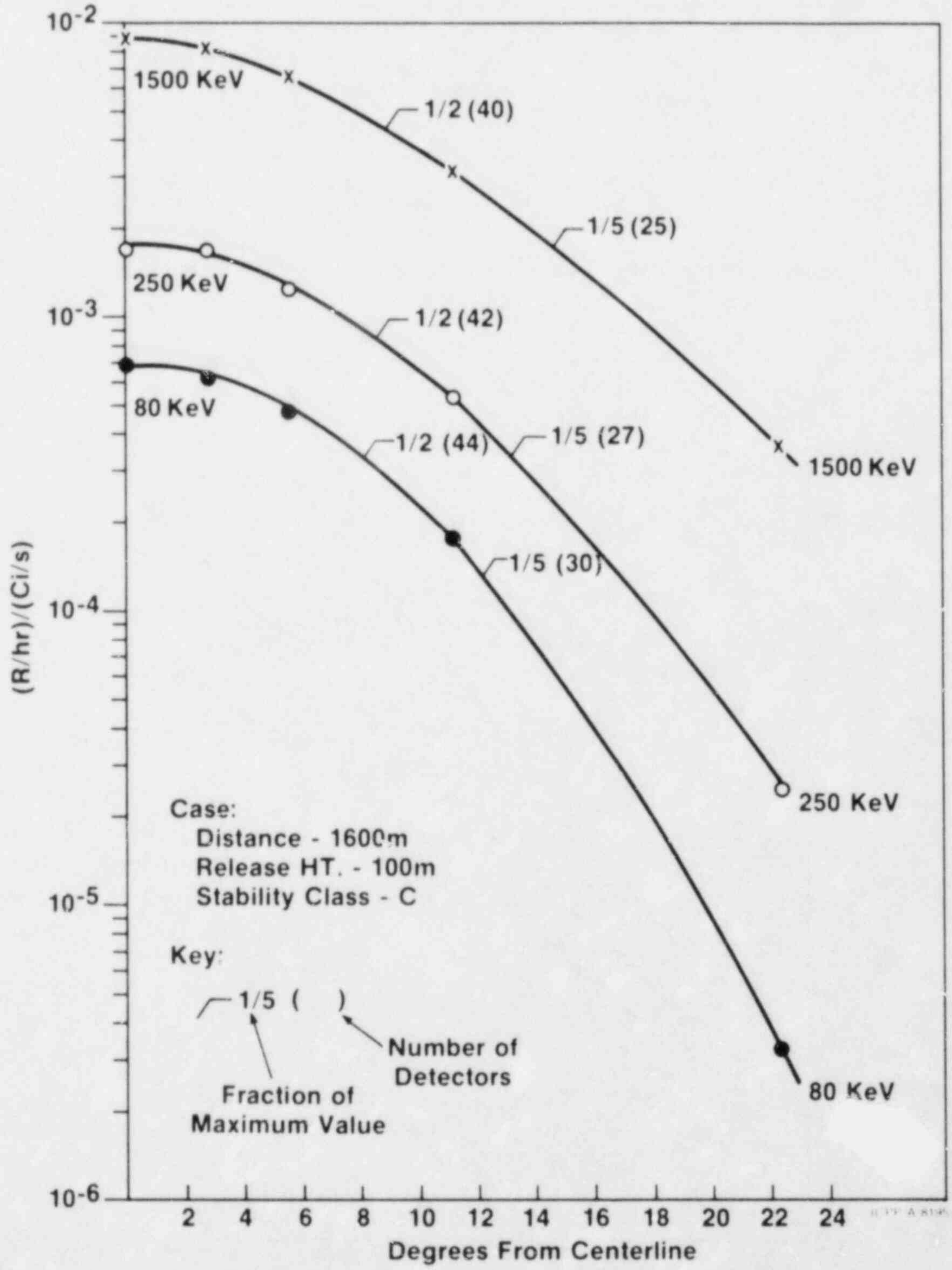

Figure 11. Detector Requirements as a Function of Cloud Dose Gamma Ray Energy

Table V. DETECTOR REQUIREMENTS

DISTANCE, m	RELEASE HEIGHT, m	AGREEMENT BETWEEN TWO DETECTORS	A	B	C	D	E	F
			WEATHER CLASS / NUMBER OF DETECTORS					
		x 2	23	30	40	58	69	90
800	0	x 5	15	19	25	36	42	51
		x 10	--	16	20	28	33	38
		x 2	25	30	39	43	46	58
800	100	x 5	16	19	24	26	29	30
		x 10	--	16	19	21	23	24
1600	0	x 2	24	32	42	65	--	100
		x 2	23	34	45	62	72	86
1600	100	x 3	18	28	36	49	57	64
		x 5	15	23	30	40	46	50
		x 2	--	44	55	69	103	138
3200	0	x 5	--	34	40	46	65	80
		x 10	--	32	36	40	55	66

Table V gives additional data for distances ranging from 800 m to 3200 m. As expected, the number of required stations increases with distance. These data also show the dependence on release height, with the worst case being a ground level release.

The effect of more energetic gamma rays from shorter-lived noble gas nuclides on the number of detector requirements has been evaluated. Plume shape and detector requirement calculations similar to those shown in Figure 9, page 26, were made for three different gamma ray energies: 80keV, 250keV, and 1500keV. The conditions assumed were class C weather stability, and a release height of 100m. The results given in Figure 11 show little change in the overall plume shape with respect to gamma ray energy and hence, little significant difference in the number of detectors required to give responses within factors of two or five of each other.

Based on the results of these calculations, it is quite evident that offsite real-time monitoring systems consisting of 16 or even 32 units may not provide information on centerline dose values and plume location because of the limited number of detectors. In some cases, especially for extremely narrow plumes (stability classes E and F), the plume might pass between two detectors and go undetected, or if detected, the magnitude of the dose associated with the plume could be greatly underestimated unless it passed directly over one of the sparsely placed detectors. Conversely, in our opinion, the installation of a 100 unit detector system is not practical, feasible or cost effective.

3.2 Building Shine and Background

Some consideration has been given to the installation of real-time monitoring systems within the confines of the site boundary; distances of 500-800 m are typical. In the event of an accident, it is quite probable that the background resulting from building shine could result in a significant signal to near-by detectors. To evaluate the magnitude of this component we calculated the dose to a receptor as a function of distance for the following condition:

1. 100% of the Krypton and Xenon isotopes and 50% of the iodine isotopes were released from the core.

2. Of these amounts 1% of each leaked to the reactor building.

3. The following reactor building contents (based on WASH-1400[14] for a 12 hr decay period).

^{87}Kr	2.4 Ci	^{131}I	1.2×10^{5} Ci
^{88}Kr	1×10^{4} Ci	^{132}I	4.8×10^{3} Ci
^{133}Xe	4.8×10^{5} Ci	^{133}I	1.7×10^{5} Ci
^{135}Xe	4.1×10^{4} Ci	^{134}I	22 Ci
		^{135}I	6.5×10^{4} Ci

4. No significant shielding (BWR).

5. Building volume = 5×10^{4} m^{3}.

Using the building contents given above, the dose rate from this source was calculated for various distances from the building using the code ISOSHLD-II[15]. The results for the rare gas and iodine components are given separately in Figure 12. These data indicate a significant increase in the normal background level (0.01 mR/hr) due to the contents of the building, especially at distances of less than 1000 m.

The question of shielding the detectors from this source has not, in our opinion been adequately resolved. Complete shielding of the detector from this source would only negate the signal from a plume. The value of partial shielding in the direction of the building shine is questionable considering the scattered radiation from the building.

To evaluate the impact of the building shine on a signal from a passing plume we have included in Figure 12 the contribution from a plume of ^{133}Xe based on the building contents given above and a leak rate of 1%/day, giving a source term of 0.055 Ci/s. Also assumed was class E weather, a wind speed of 1 m/s, a release height of 100m, and that the bulk of the iodine was retained in the reactor building or trapped by the filter system and therefore had no significant contribution to the plume dose.

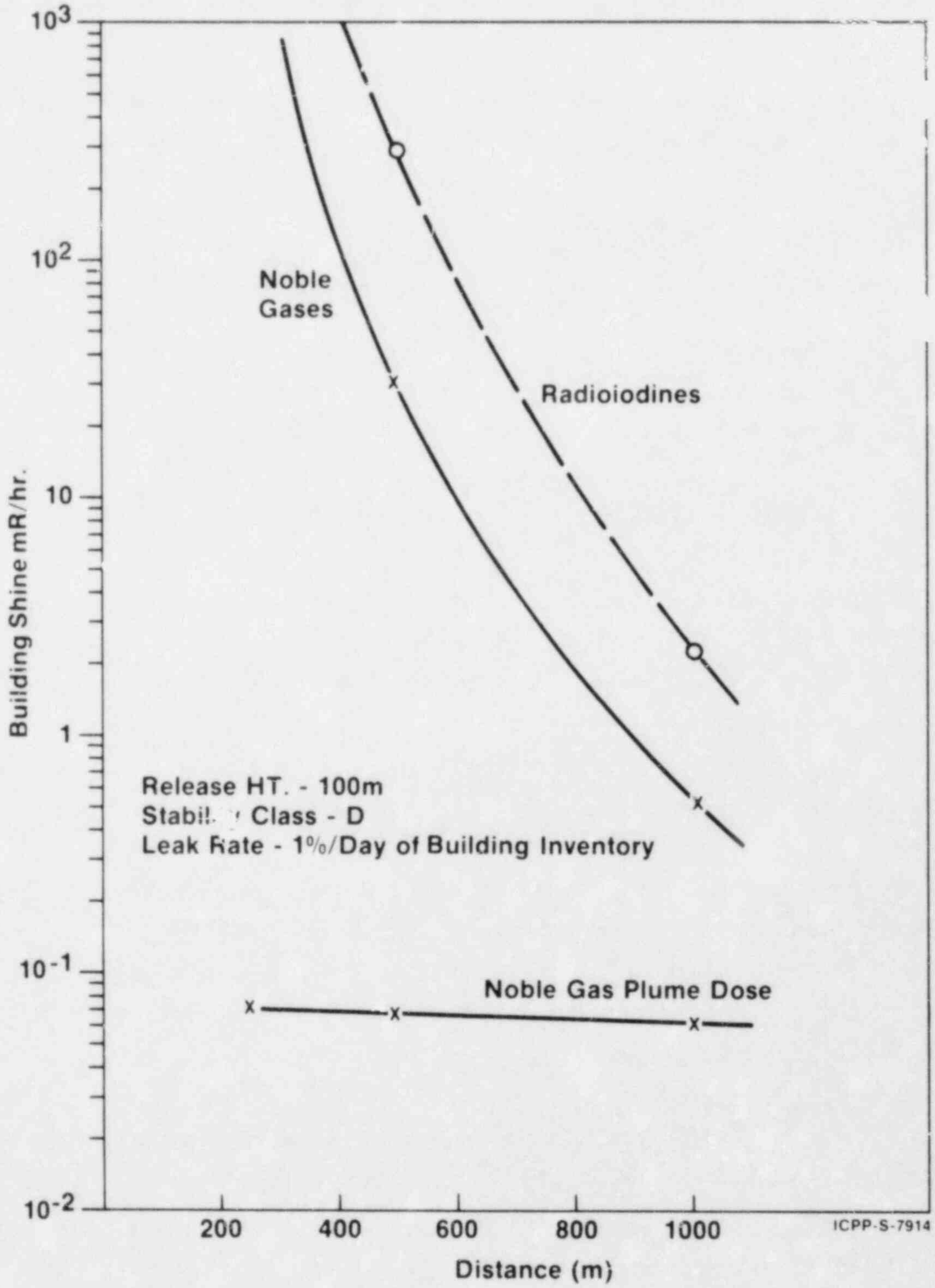

Figure 12. Effect of Building Shine on Detector Response

The results of this calculation clearly show the significance of the building shine factor relative to the plume dose. For the accident case where significant quantities of the volatile radioactive products are in the reactor building, little or no information regarding the plume dose could be obtained from detectors located close to the reactor building.

4.0 INSTRUMENTATION REQUIREMENTS, AVAILABILITY AND SYSTEM COSTS

The basic components of an offsite real-time monitioring system are shown in Figure 13. Also identified, are the major cost areas to be considered in establishing an offsite, real-time monitoring system. Currently, virtually all of the existing real-time monitoring systems which have been installed are for the purpose of monitoring routine releases rather than for use in emergency situations. Although the immediate use is different, the equipment and costs should be similar. Because many of these systems have only recently been installed or are in the installation stage, little information or cost figures are available in the open literature.

To obtain the information necessary to establish an estimate of the costs involved in the installation of a system for use in an emergency situation, several utility stations and state agencies were contacted. These nversations ranged from rather open discussions to quite guarded comments, and in some cases, a reluctance to quote cost values. Also vendors of potentially useful instrumentation were contacted.

A review of the instrumentation requirements and availability of real-time monitoring systems is given in Section 4.1. Section 4.2 gives a review of total system cost and an estimate of the installation costs based on information gathered for existing or planned systems.

4.1 Instrument Description and Requirements

The basic requirements for an offsite, real-time monitoring system are listed below and shown diagramatically in Figure 13.

4.1.1 Field Stations. Field Stations will consist of radiation detecting devices and associated electronics. The stations would preferrably have the capability of signal averaging and onsite readout. The radiation detection system should be capable of measuring dose rates

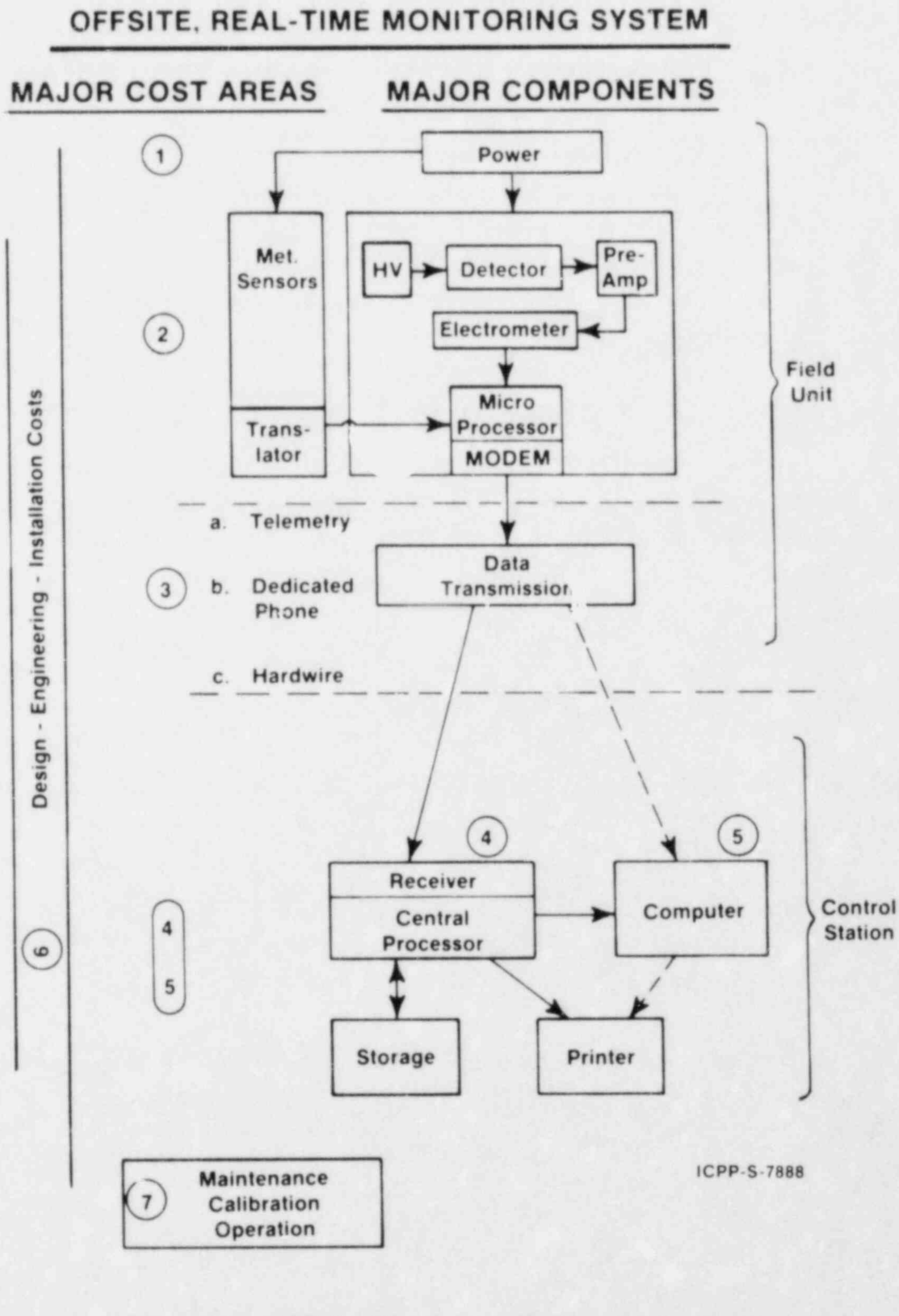

Figure 13. **Schematic of Offsite Monitoring System Basic Components**

from 1μR/hr to 10 R/hr with reasonable accuracy (± 10%) and respond in a relatively flat manner to photons of 50 to 3000 keV. The detector(s) should be weather proof and the associated electronics enclosure maintained at suitable operating conditions. This may require heating or cooling depending on site conditions. For the winter of 1981-2, the heating requirement could be significant. A provision for backup power should be made.

Additional instrumentation, such as meteorological sensors and iodine sampling devices may be added to the field stations. This additional instrumentation may provide useful data but the cost per field station will be increased.

4.1.2 Data Transmission. Three practical methods exist for transmitting data from the field stations to the central processing unit and commands from the central processing unit to the field stations. These include direct hard wire connections, dedicated telephone lines and radiotelemetry. The choice for specific site will depend on economic and environmental factors. The selected system must be capable of:

1. Bidirectional operation,
2. Error detection and correction,
3. A useful transmission rate, and
4. A transmission structure compatible with the accumulated data.

Direct wire connections often provide the most reliable connections. However it may be impractical to use hardwire connections over water or at distances greater than one mile.

Telephone systems using voice grade lines for data and command transmission can be installed by and then leased from telephone companies. Bidirectional transmission is preferred, although half-duplex is adequate.

Several commercial vendors including those of real-time environmental monitoring systems supply compatible telemetry systems. Line of sight transmission of up to one mile can be performed using an FM system.

As with other field stations electronics, transmitters and encoders must be protected from the environment and, at colder sites, heated.

4.1.3 Central Processing Unit (CPU). The CPU performs the acquisition, reduction and storage of data describing radiation dose rate conditions existing at each field station. The CPU also performs the following functions: 1) diagnostic testing of these data to provide dose rate and meteorological condition time average values for each station, 2) the comparison of radiation data to alarm points, 3) compilation of historical data files, and 4) polls the field stations for radiation dose rate levels at requested intervals. The CPU also should have an interface for transferring the acquired data to an external computer for plume analysis, characterizations, and the ultimate prediction of downwind dose values. Hardware required for these tasks include:

1. Data receiver and decoder
2. Microprocessor,
3. Data storage device,
4. Printer,
5. Command entry device, and
6. Back-up power supply.

4.2 Instrument Availability

The capital costs of obtaining and installing an emergency monitoring system were estimated from costs of existing routine monitoring systems. To prepare capital cost estimates for an emergency monitoring system, three vendors of routine monitoring systems (GCA Corporation, Harshaw Chemical Company and Reuter-Stokes) were contacted. None of these vendors offer systems which are capable of simultaneously monitoring routine radiation releases and meteorological conditions, transmitting this information to a CPU which subsequently models the release and provides dose rate characteristics. The existing systems provide real time remote location dose rate data which is transmitted to a CPU and converted to information such as count or dose rate averages, anomalies and alarm points. All three vendors offer a CPU which can be interfaced with an external computer for characterizing and predicting dose rates. It is interesting to note that the only external computer that each of the three vendors recommends interfacing to their CPU is the Digital Equipment Corporations PDP-11/34. Details of the features, capabilities and price for each of the three systems are discussed below and summarized in Table XI.

GCA Corporation

The GCA Corporation has installed several of their "Guardian" systems at power stations in the United Kingdom for the purpose of providing routine real-time environmental monitoring. The "Guardian" system employes two GM detectors (low range, 10^{-6} - 10^{-2} R/hr, and high range 10^{-3} - 10 R/hr) at each field station for radiation detection. In addition, a "Maypac" particulate and iodine filter system with constant air pump can also be placed at each field station. Data transmission from the field stations to the central processing unit is usually performed by VHF radiotelemetry, but other methods are possible. The "Guardian" CPU provides immediate hard copy and visual display of current field station readings, system diagnostics, and data logging. Although the "Guardian" system has been marketed in the USA since 1981 it has not been installed and operated at any power station in this country. Installation costs and operational characteristics of this system can be obtained by contacting power station personnel in the U. K.

The Harshaw Chemical Company

The Harshaw TASC-4 systems may be used for routine real time environmental radiation monitoring. This system uses two scintillation detectors per field station to give monitoring capabilities over seven decades of signal. Data transmission from the field stations to the CPU is by dedicated hard wire systems because generally the units are used inside of buildings where the distances are short. An advantage of the Harshaw TASC-4 system is that all field station electronics, except the preamplifier, can be placed in the CPU thus minimizing the effects of weather on the system, lowering the potential for tampering at the field stations, and centralizing much of the maintenance. Components of the CPUs of these systems also include counter-timers, printer, and computer interface modules. To date none of these systems have been installed to function as routine real time monitoring devices at distances being considered in this study.

Reuter-Stokes

The Reuter-Stokes Sentri-1011 system, designed specifically for real time routine radiation monitoring, has been installed at several nuclear power stations in the USA. The field stations of the Sentri 1011 systems are equipped with high range (10^{-3} - 10 R/hr) and low range (10^{-6} - 10^{-2} R/hr) pressurized ion chamber detectors and associated instrumentation. Reuter-Stokes is presently developing a single detector to provide accurate monitoring over seven decades of signal which should result in a reduction of a capital cost and installation. Data transmission from the field station to the CPU of the Sentri-1011 system can be accomplished by radiotelemetry, dedicated telephone lines, or hard wire. The Sentri-1011 CPU performs field station data reduction, system diagnostics, and data logging. Historical information can be obtained in hard copy and the unit contains an interface port for an external computer.

Reuter-Stokes is the only vendor which offers a compatible meteorological accessory package for their field stations. This package, the "3-D Wind System," is marketed by Climatronics and is described in Table VII.

4.3 System Costs

Several commercial power reactor stations and state radiological monitoring agencies were contacted relative to obtaining cost information regarding the purchase and installation of offsite, real-time monitoring systems. Although the systems which have or are being installed are for the purpose of monitoring routine releases, the basic instrumentation and cost data should be similar for an emergency montoring system. In some cases, detailed cost information was not available because the systems were still being installed or existing systems were being modified or expanded. Information regarding date of installation, number of fixed stations, distance from the source, and type of data transmission is given in Table VIII. All of these systems are using the Reuter Stokes Sentry-1011 monitoring system.

The cost factors for these systems are quite variable because of varying degrees of instrumentation complexity and whether a subcontractor was involved in the design, purchase, and installation of the system. The range in the costs per monitoring unit is approximately from $20,000 to $40,000/unit. In general, the higher priced systems included a meteorological sensing component and/or additional subcontractor costs. For purposes of this survey an average cost of about $30,000 per unit appears reasonable. This value includes the costs of all monitoring and data transmission instrumentation. The cost of a central data processing unit and a computer for extended data handling and reducing capibilities is variable depending on whether dedicated or existing hardware is used for this purpose.

A much more ambiguous cost is that regarding the installation of the field units. If the monitoring unit is installed on existing supports (power transmission poles) and the power source is readily available, the installation costs may only amount to a few thousand dollars ($3,000 - 5,000) per unit. Conversely, if special supports are required or if the units are installed over water, the average station costs could increase five fold ($25,000/unit). Additional cost would also be incurred if special power lines and installation are required. For example, use of uninterrupted power from the Auxiliary Building could add several hundred thousand dollars to the overall costs.

Other costs which must be considered but are difficult to quantify include design and engineering, purchase of land if necessary, depreciation, routine maintenance, dedicated telephone line leasing fees, and operating cost. The last item could be significant if a group of dedicated operators (meteorologists) were assigned to operate the system and evaluate the data.

Based on the data currently available, the following range of cost figures are given for a 16 unit station at a distance of 2 miles.

	Range of Costs (000)
1. Instrumentation $20-40K/unit	400 - 640
2. Data Collection and processing equip.	40 - 110
3. Installation $5-25K/unit	80 - 400
4. Design and Engineering	50 - 200
5. Contingency	100 - 200
	$670 - $1,610

The lower cost figure does not insure uniform placement of the monitoring units because existing support poles are considered for use. Thus, it is quite probable that a release could go undetected if it consisted of a compact plume (stability class E or F). Considering that we are only referencing a 16 unit system this same comment could apply even if the monitoring units were uniformly spaced on a ring. Therefore, one could raise a question regarding the technological validity of the entire concept. To increase the number of stations to give highly reliable measurements would result in increasing the overall cost of a system by several million dollars.

TABLE VI
VENDOR DATA FOR REAL-TIME MONITORING SYSTEMS

	Field Station Detector Electronics	Data Transmission	Central Processing Unit (CPU)
Harshaw Chemical Co. TASC-11			
Features	Two weatherproofed CaF_2 (Eu) Scintillation detectors. Wired power backup.	Hard wire.	All field station electronics except preamplifier are at CPU.
Capabilities	Two detectors span seven decades of signal (1μR/hr - 10 R/hr). and withstand temperature variations of 15^oC/hr.	Hard wire use demonstrated up to one mile.	Field station electronics at CPU record and print out monitoring data. External computer required for other data reductions and displays.
1981 Prices	$7K per station including electronics.	Included in field station price.	$4.2K for CPU consisting of computer interface, data recorders, counter and timer.

TABLE VI (Cont'd)
VENDOR DATA FOR REAL-TIME MONITORING SYSTEMS

	Field Station Detector Electronics	Data Transmission	Central Processing Unit (CPU)
GCA Corporation "Guardian"			
Features	Two weatherproofed GM detectors, digital display, detector range changer, solar powered battery backup and "Maypac" particulate and iodine filters. Automatic detector range changer.	RF telemetry, dedicated telephone, hard wire.	CPU has teletype printer, visual data display, data storage, alarm and status system, and external computer interface.
Capabilities	Two detectors span seven decades of signal (1μR/hr - 10 R/hr) with $\pm$ 5% accuracy at 10μR/hr. Energy response between 60 KeV and 3 MeV is $\pm$ 20% Temperature operating range -10^{o}C to +60^{o}C.	Hard wire or dedicated phone line possible.	Processes data from up to 31 field stations. Field stations scanned at 5 second intervals in system alarm mode, 5 minute intervals in in non-alarm mode.
1981 Prices	$15K per station with telemetry $10K per station with hard wire or telephone.	Included in station cost	$50K

TABLE VI (Cont'd)
VENDOR DATA FOR REAL-TIME MONITORING SYSTEMS

	Field Station Detector Electronics	Data Transmission	Central Processing Unit (CPU)
Reuter - Stokes Sentry 1011			
Features	Two weatherproofed pressurized ion chamber detectors. Digital display, strip chart recorder, 8-hour battery power backup, serial readout and automatic detector range charger.	Hard wire, dedicated telephone, or RF telemetry.	Basic CPU processes input from 16 field stations, reduces and stores exposure rate data. CPU also has alarm and system diagnostics, and external computer interface.
Capabilities	Two detectors span seven decades of signal (1μR/hr - 10 R/hr) with ± 5% accuracy at low levels. Temperature operating range is -25°C to + 55°C.		Basic CPU can be upgraded to process input from up to 48 field stations. Scan of field stations can be done at 5 second to 5 minute intervals.
1981 Prices	$11.3K per station (detectors cost $3K a piece)	$3.5K per station for telemetry. Hard wire about $2K per station at 0.5 miles.	$39K to process input from 16 stations. $70K to process input from 48 stations.

TABLE VII
Climatronics "3-D" Metorological Montoring System

	Field Station Electronics	Data Transmission	Central Processing Unit (CPU)
Features	Sensor package inputs to field computer to determine θ and Φ Can use dedicated telemetry for radiation detection electronics for transmission. Ten meter tower, sensor heater and electronics housing required.	Dedicated 2-way telemetry system recommended for real-time monitoring but telephone and hard wire is possible.	Field computer output transmitted directly to modeling system to determine stability class.
Capabilities	Solar power, temperature dew point sensors also available.	Two-way RF can relay commands to station such as time averages and scan times.	Station sensors used with doppler monitor for forecasting would give more information for modeling.
Cost[a]	$10K/station for the above features and capabilities.	$3.5K/Station for 2-way RF telemetry	$3K for RF central processing unit

[a]1981 purchase prices

TABLE VIII
REAL-TIME INSTALLED MONITORING SYSTEMS

Facilitity (Owner)	Installation Date	Number of Monitoring Units	Distance from Sources (miles)	Data Transmission
Diablo Canyon[a] (PG & E)	1981	12	5-10	Phone
La Salle (Comm. Ed)	1980	8[b]	2	Phone
Berwick (Penn. P & L)	1980	2[c]	15-26	None
Virgil C. Summer[a] (SC G & E)	1981	8	0.5	Hardwire
Three-Mile Is. (Metro. Ed)	1980	12	0.1-4	Phone
Indian Pt. -2[a] (Con. Ed.)	1980	16	0.5-2.5	Telemetry
San Onofre (So. Cal. Ed.)	1981	9[d]	0.6	Phone

a) Field stations include meteorological accessories
b) When completed system will have 16 field units
c) Complete system will have 7 field units
d) Complete system will have two rings of 9 stations each. One at 1000m and the other at 2000m.

5.0 MATRIX EVALUATION

One of the primary objectives of this program is to evaluate the concept and usefulness of an offsite real-time monitoring system in the light of a matrix array and associated parameters. The matrix and its three major components, accuracy, cost, and detector sensitivity were presented in Section 1. Based on the review and studies conducted in the prior sections of this report our evaluation of the matrix is as follows. For ease of reference the matrix array is reproduced on page 51 as Figure 14.

Accuracy - The accuracy level was evaluated based on the uncertainty associated with the quantification of an unmonitored release in the presence of a monitored release. Based on our study we propose eliminating all conditions associated with accuracy values for factors of 2, 5 and 10. In some cases, especially for the case where the unmonitored release is small compared to the monitored release, even the accuracy factor of 50 for the unmonitored release may be a question.

Detector Range - The requirement for detectors sensitive to the measurement of a quantity of radiation equivalent to 0.1 background (1 μR) cannot be justified, especially when the background can fluctuate more than this amount. A similar argument can be made for detector systems having a lower range equivalent to background (10 μR/hr) because the uncertainty in the signal would be large and a reading equivalent to background in an emergency situation would not be significant relative to the initiating protective action in the surrounding areas. One might make a case for the use of detectors having a lower range of 10 μR/hr in establishing site specific diffussion models based on the monitoring of normal releases. However, if the detectors are placed at a two-mile distance from the plant, the dose rate from normal releases would be so small as to be garbled in the normal background fluctuations. In our opinion, detectors with a lower range of 10 times the background level or 0.1 mR/hr should be adequate for an offsite real-time monitoring system, because readings of less than 0.1 mR/hr are of little significance from a hazard standpoint. This is a point which should be presented as part of the public relations effort of the utility. This conclusion eliminates the two lower levels of the matrix.

Cost Factors - This item is more difficult to assess because of the wide range of values associated with the installation costs. We can, however, make some general comments. If a low cost system is installed with a minimum (8-12) number of stations, there is a high probability of missing a plume, in which case the system has little technological value. To install a minimum system with detectors only near population centers may have appeal from a public relations standpoint but it does not provide the technical data which is necessary to assess the impact of a plume to the rural areas which could be populated by grazing milk cows. Also, if the detectors were not uniformaly spaced near the population centers, false information relative to the intensity of the plume dose could result.

We do not support the installation of a minimum system, which we are associating with a $250,000 cost value, because the technical information obtained from such a system would be of questionable use in a decision making process.

Similar arguments can be made for a $750,000 system; however, at this level each installation would have to be evaluated on an individual basis because of site specific characteristics. Obviously the requirements for a monitoring system in a flat terrain situation is different from one involving water, off-shore and on-shore breezes etc. In some cases, a system constructed for a cost of $750,000 might provide reasonable technical information. Thus, we have decided to leave this area of the matrix open but emphasize the site specific characteristic of the case.

For $2,000,000 one might construct a reasonable system, but in no case would information accurate to a factor of 5 or 10 be obtained. In fact, almost no sum of money would insure obtaining dose values to this level of accuracy.

Based on the above discussion and evaluation, the bulk of the matrix has been eliminated. The remaining areas which we feel identify the potential benefits and associated uncertainties from the installation of a fi ed off-site real-time monitoring system are shown in gray in Figure 14. While it is acknowledged that our conclusions are argumentative, we believe they are representative of the current state the of art.

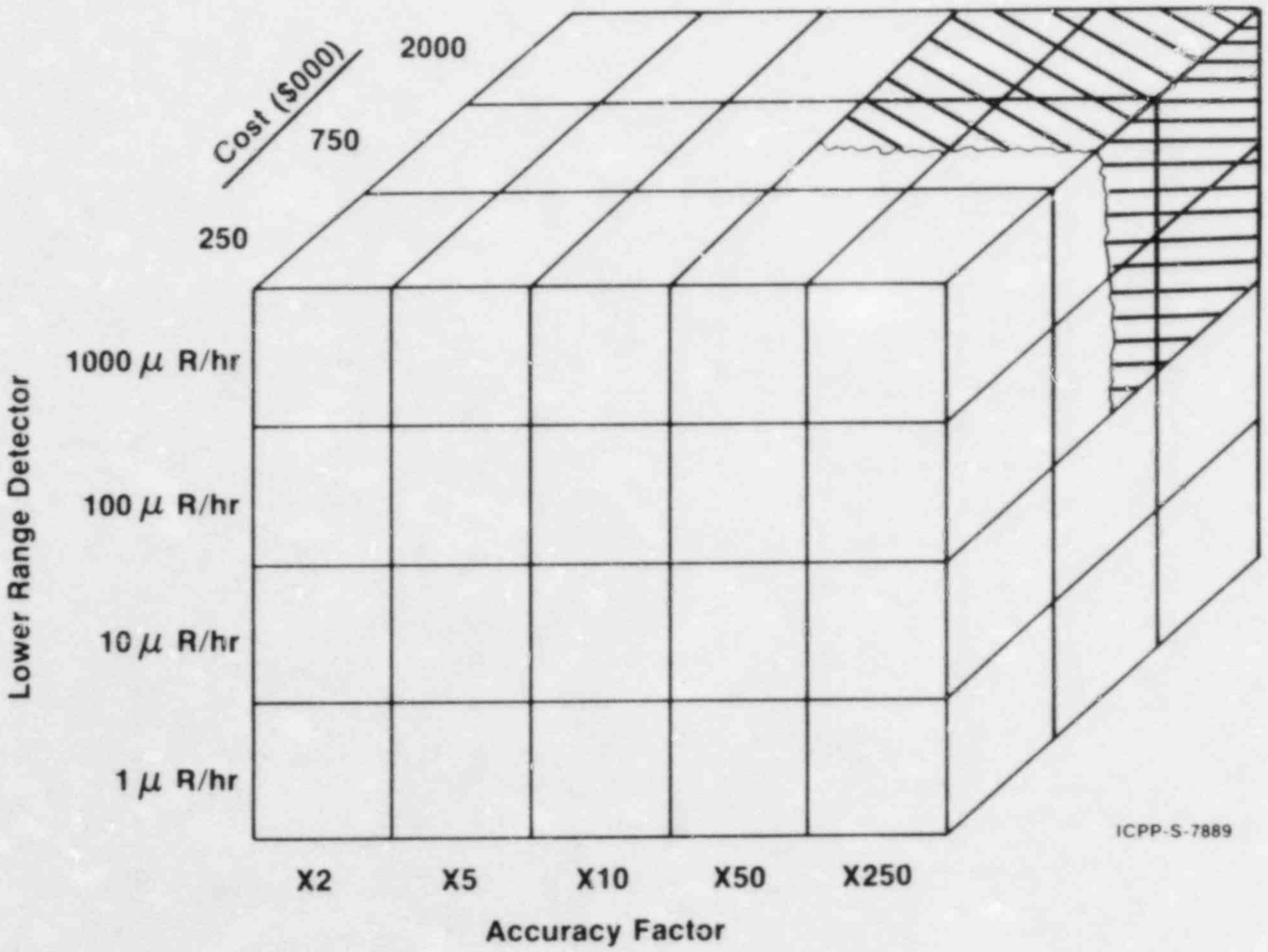

Figure 14. Matrix Parameters

6.0 MINIMUM-COST EMERGENCY SYSTEM

An augmented effort to the general program involved the characterization and evaluation of a specific, minimum cost emergency system with close proximity to the plant. The constraints to be applied to the evaluation of such a system are as follows:

1. Total system cost - not to exceed $500,000,

2. Detector assembly cost - not to exceed $7,000/unit

3. Detector distance - no further than 800 m (0.5 mi),

4. Detector sensitivity - 0.1 mR/hr to 10 R/hr, and

5. Accuracy - within a factor of 10.

Using the cost data presented in Section 4, the following values were used to establish the magnitude of the system which could be installed within the $500,000 constraint.

Fixed Costs

Central Processor (with modeling, 48 station capacity)	$110,000
Design and Engineering	40,000
	$150,000

This leaves a balance of $350,000 which can be allocated to the cost of the detector assembly, data transmission, and installation. The cost per station is estimated as follows:

Dectector Assembly		$ 7,000
Data Transmission/Unit		8,000[a]
Installation/Unit		3-15,000[b]
	Total/Unit	$18-30,000

---

[a] Includes capital cost and installation

[b] highly variable depending on specific location

For this exercise it was assumed that the data transmission would involve a telemetry system because the cost of installing hardwired or dedicated phone systems is highly variable. For example, climatic factors may dictate the burial and/or the use of special materials in each of these data transmission systems. The installation costs are based on simple units all installed on flat solid terrain. If uniform placement of the detector assemblies required installation in cooling ponds, rivers, or other bodies of water, the installation costs would increase significantly, perhaps by as much as a factor of five for those units in such a location. Another significant expense item is the power source. If an uninterrupted power supply from the Auxiliary Building is used the cost per station would be significantly more, especially if underground or underwater lines were used.

Based on an after fixed-cost balance of $350,000 which can be allocated to the detector units, and a range of average station costs of $18,000 - $30,000, from 12 to 20 detector units could be installed depending on the actual placement of the units.

The 12 unit system would insure equal placement of the units regardless of the location. The 20 unit system could have voids in the monitoring grid and be operated with normal power sources.

The estimate appears reasonable based on information obtained from two utilities which provided cost information for a comparable system. One station which recently completed installation of an 8 unit system at a distance of 800 m (0.5 mi) quoted a cost of about $435,000 for the purchase and installation of the package. In this case, each unit also included a meteorology station and the output from the unit was hard-wired to the control station and coupled to an existing HP-1000 data processer. Thus, the total cost per unit is approximately $54,000.

The overall cost would increase if a dedicated CPU were used and probably decrease if some other form of data transmission were used. The cost per unit would also decreasing if meteorology sensors were not installed with each unit, but the validity of any down-wind projection would also decrease.

A second utility while not providing complete capital cost data did provide sufficient information to estimate the cost for a ring of nine units at a distance of 1000 m. The central processing unit for this system has not been purchased. However, the purchase cost of the nine field stations was about $135,000, or about $15,000 per station. For the nine unit system using a dedicated phone system for data transmission, the installation cost per unit was quoted at about $23,000 per unit or about $200,000 for the system. This is somewhat higher than our estimate but gives some idea of the costs involved just for installation. Assuming fixed costs of $150,000 for design, engineering, and a central data processer, about $135,000 for instrumentation and $200,000 for installation gives a sum within the $500,000 constraint. The unit cost for the nine detector system is about $55,000, which is similar to the first system discussed.

To estimate the credibility of the data which could be expected from an 8 to 20 unit system we first considered the data given in Table V. Based on these data, a minimum of $\sim$90 equally spaced stations would be required for two adjacent units to give a reading within a factor of 2 of each other when the release was at ground level and the stability class was F. For two units to agree within a factor of 10 would require a system of 35-40 units. About 30 detectors would be required for more common class D weather. These numbers are based on the assumption that the centerline of the plume passes directly over one of the stations. This is a highly unprobable event. The passage of a plume between two detectors would give a response which underestimates the true magnitude of the release.

A second factor which must be considered for a 500-800 m system, is the effect of the building shine factor, especially for a BWR. For the case given in Figure 12, the plume dose at 800m for a leak rate of 1% per day of the building noble gas inventory is considerably less than the building shine background. The effect of building shine will be much less for a PWR.

The effect of building wake and dispersion of the flow regime by other buildings (other than the reactor building) is a third factor which should be considered. This effect could significantly alter the measurement of the true dose from the plume.

While a close-in detector system might in some instances provide some information in an emergency situation, the ability to extrapolate and project the information to give concentration or dose values at some extended downwind distance (5-10 mi) is highly questionable. This could only be done with a reasonable degree of confidence if site specific modeling and additional downwind meteorological data were available.

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APPENDIX - A

BRIEF SUMMARY OF EXPERIMENTAL RESULTS TO COMPARE MEASURED AND PREDICTED GROUND LEVEL CONCENTRATION VALUES

A.1 ^{85}Kr Experiment at Savannah River Plant[9]

In this experiment, the release of ^{85}Kr from the Savannah River Plant chemical separations facility was monitored for over a year at six sites within 10 km of the release points. Using the Gaussian plume model for a continuous source, the ratio of the predicted concentration to the measured concentration was determined. The dispersion parameters were those based on the ideal case of flat terrain, short distance, and steady meteorological conditions.

The general results showed that the annual average concentrations were over-predicted by a factor of 2 to 4 compared to the measured values. For the short-term (10 hours), the predicted values were within about a factor of 10, and in many cases, particularly in calm or stable conditions, measurable concentrations were predicted when none were observed. The results of the short-term data are shown in Figure A-1 from Reference 9.

A.2 ORNL Assessment of Hanford Experiment[10]

As part of a DOE sponsored program associated with the Breeder Reactor Program, ORNL is evaluating experimental data obtained from an experiment conducted at Hanford in which zinc sulfide fluorescent particles were released from a height of 111 m over relatively smooth terrain. Crosswind-integrated ground-level air concentration measurements were compared with predicted values using a Gaussian plume atmospheric dispersion model. Of interest was the use of three different sets of measurements to calculate the atmospheric stability class.

a. The vertical temperature difference between 10 and 122 m above ground-level,

b. The standard deviation of the wind direction measure at a height of 122 m, and

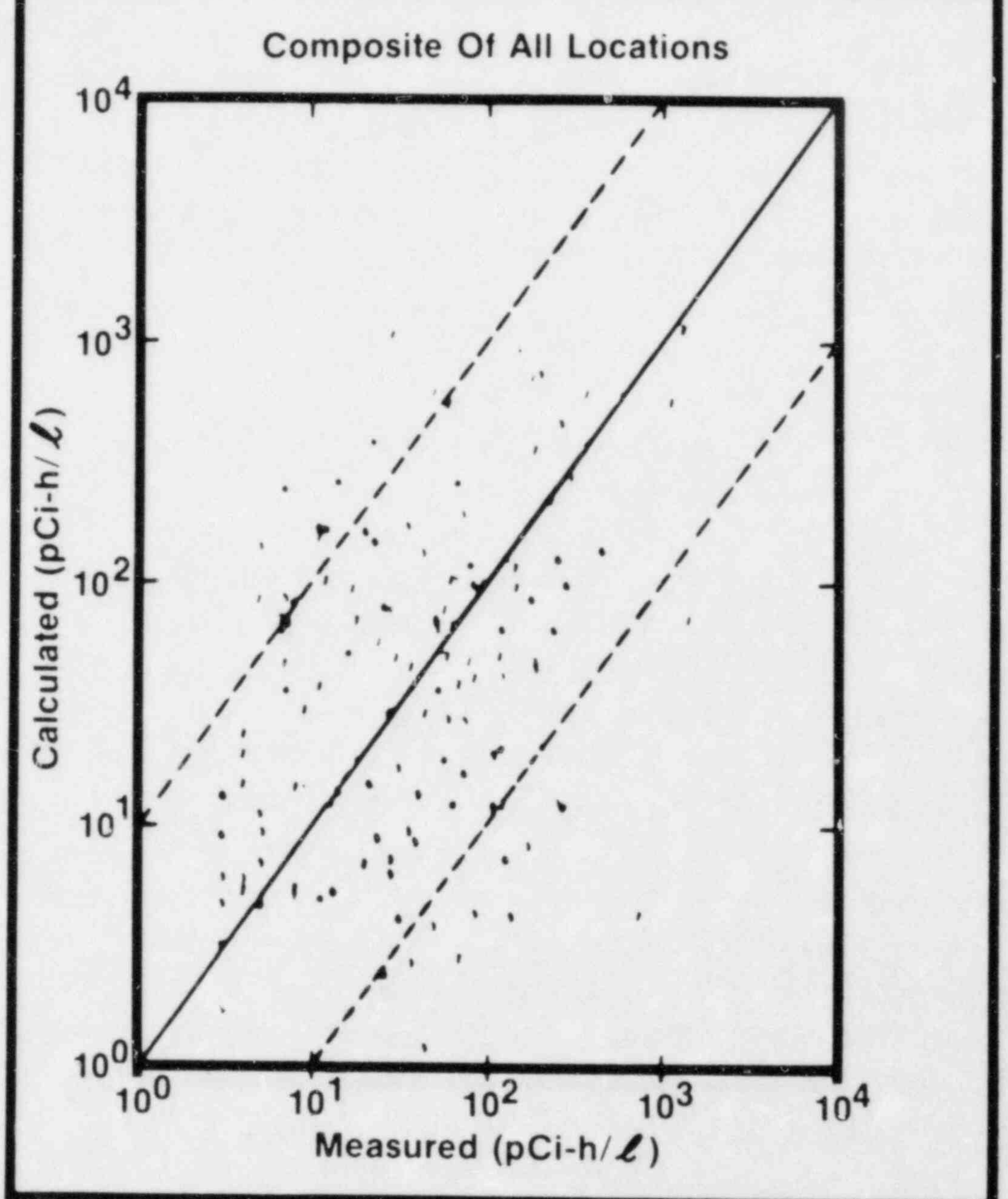

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Figure A-1. Measured to Predicted ^{85}Kr Concentrations (ref. 9)

c. A combination of a and b.

For the Hanford data, methods a and b, with one exception, indicate Pasquill stability classes E or F, while method c always indicates class D.

In this study ORNL compared the results obtained as a function of the dispersion factor, σ_z, based on five different sets of diffusion models. Basically, these include those data sets previously discussed and reviewed by Brenk[8] (Pasquill, St. Louis, Briggs' Rural, Brookhaven, and Julich-100 m). Separate comparisions were made between measured and predicted concentration values using each of the five sets of σ_z values and three stability class determinations. A summary of the observed and predicted concentrations values is given in Table A-1.

These data (Table A-1) show that the predicted values differ from the measured values by a factor of 5 to 10 more than 50% of the time and that the predicted value may be more or less than the measured value depending on the dispersion system used and the associated dispersion factors. About 40% of the time the difference between the predicted and observed values can be a factor of 10 or greater; again in either direction.

These data tend to support our initial comments regarding uncertainties associated with the use of the standard Pasquill factors and the need to develop site specific data.

A.3 Excerpts from a Workshop on the Evaluation of Models Used for Environmental Assessment of Radionuclide Releases[11]

The work ; group suggested some tentative accuracy statements on the estim f airborne concentrations. These statements are largely based on ific judgement; there are not enough data upon which to base statistical estimate. For the ideal situation of a highly ins flat-field site from which previous data on meteorology

Table A-1. EVALUATION OF HANFORD EXPERIMENT BY ORNL.

Stability Assignment Method*	% of Observations Exceeding Limits					
	Factor of 5 or Greater		Factor or 10 or Greater			
	(a)	(b)	(a)		(b)	
Pasquill-Gifford	62%	52%	43%	UP**	38%	UP
St. Louis (Smith)	62%	57%	38%	UP	38%	UP
Briggs' rural	43%	48%	29%	UP	33%	UP
Brookhaven	62%	52%	52%	OP	52%	OP
Julich (100 m)	62%	62%	43%	OP	38%	OP

* (a) Stability class based on vertical temperature difference between 10 and 122 m above ground level.

(b) The standard deviation of the wind direction measured at a height of 122 m

** UP - Model underpredicts ground level concentration relative to observed values (i.e $\frac{obs.}{pred.} > 1$ majority of time).

OP - Model overpredicts ground level concentration relative to observed values (i.e $\frac{obs.}{pred.} < 1$ majority of time).

and airborne concentrations were available, it should be possible to estimate to within ±20% the ground-level centerline concentrations from a continuous point source at downwind distances of less than 10 km.

For a specific hour and downwind receptor point, the accuracy is very dependent on the calculation of the exact plume trajectory during a short period. For flat terrain and relatively steady meteorological conditions and distances of 10 km or less, the airborne concentrations for an individual case should be estimated to within about a factor of ±J. For annual average concentrations values, the accuracy estimate is about a factor of 2.

For a complex terrain or meterological situations (e.g., sea breeze regimes) a few experiments have indicated departures from estimates from the Pasquill-Gifford curves of more than a factor of 10. However, there are insufficient data upon which to base even a "scientific judgement" estimate of accuracy.

A.4 Results of a Survey of Programs for Radiological Dose Computations[12]

A standard accident release problem was presented to several nuclear facilities with the request that the cloud gamma dose be calculated as a function of distance. The same input data were used by all participants. The results of the various calculations using identical input are shown in Figures A-2 and A-3. The range in the calculated values is a factor of ~10 at the 1000-3000 m distance. Considering that there are no absolute standards by which to judge the accuracy of the dose calculations, one might question, "how close is the range of values presented by these calculations to the true absolute value?"

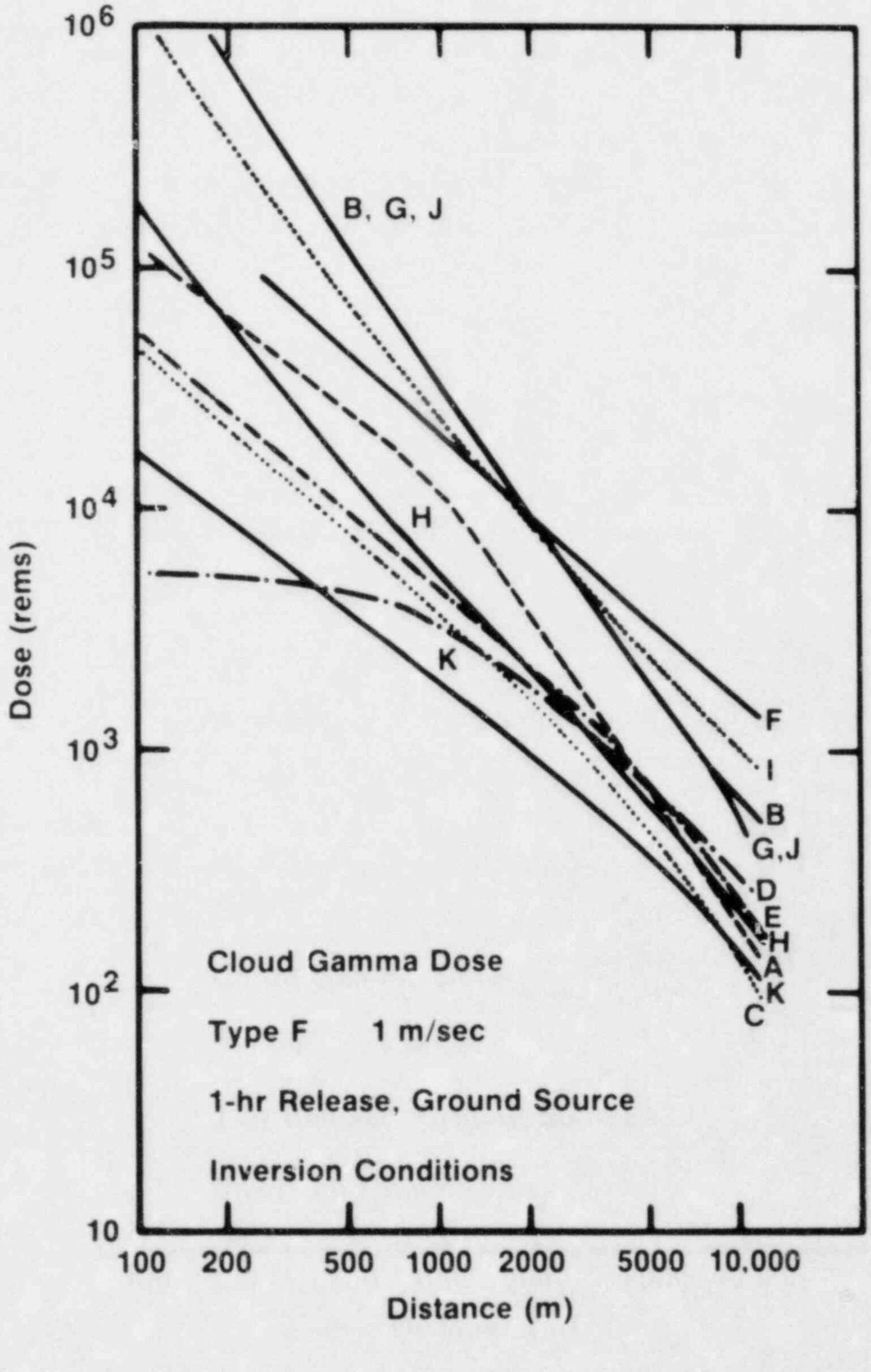

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Figure A-2. Comparison of Different Dose Calculation Models, Class F (ref. 12)

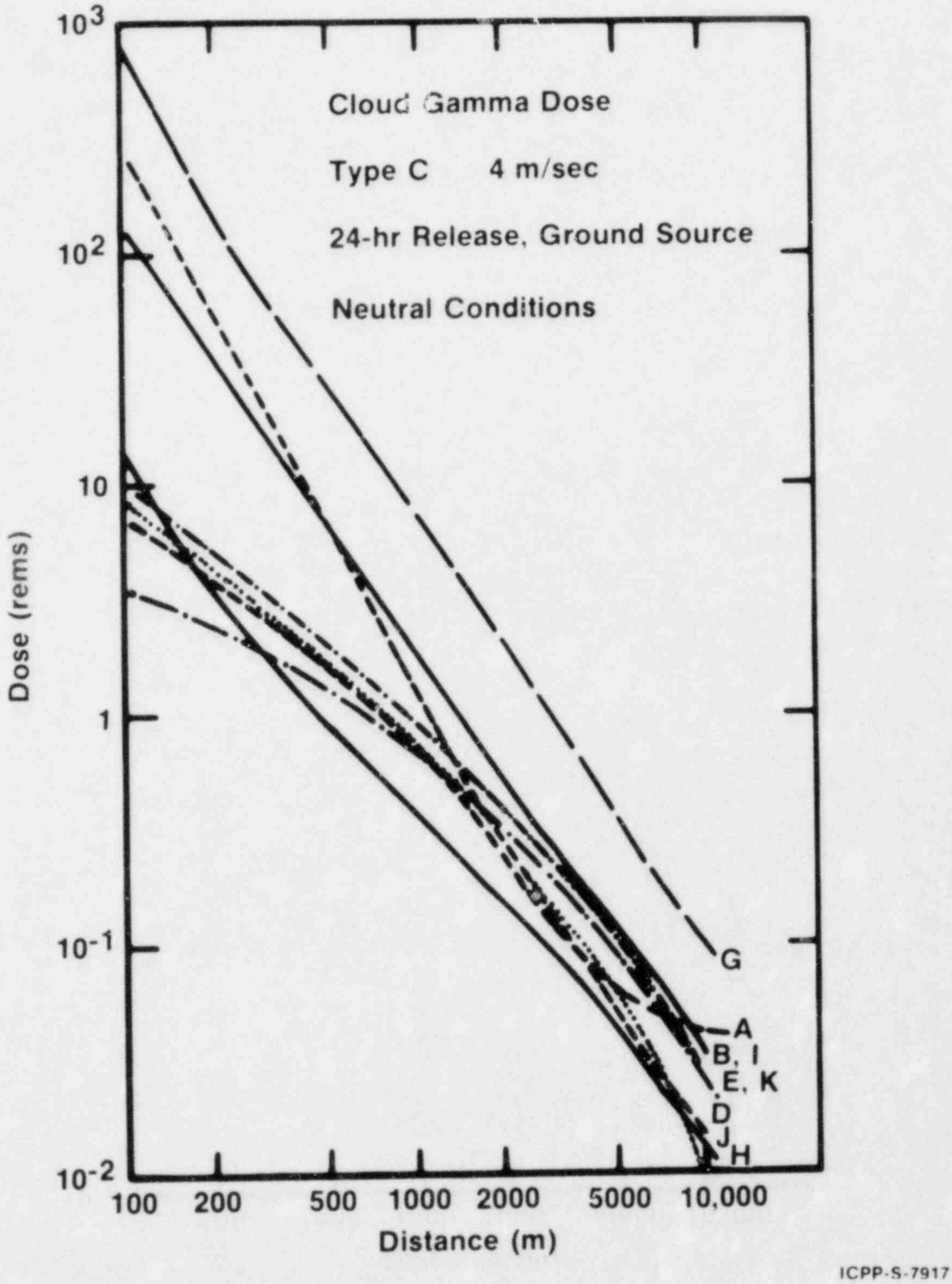

Figure A-3. Comparison of Different Dose Calculation Models, Class C (ref. 12)

APPENDIX B

VALUES FOR σ_y AND σ_z USED IN DOSE CALCULATIONS

TABLE B-1

VALUES FOR σ_y AND σ_z USED IN DOSE CALCULATIONS[a]

Stability Class	Distance 500 m		800 m		1600 m		3200 m	
	σ_y	σ_z	σ_y	σ_z	σ_y	σ_z	σ_y	σ_z
A	106	128	164	326	312	1530[b]	586	8294[b]
B	80	53	125	98	239	278	449	920
C	57	35	88	54	167	99	313	176
D	37	19	57	27	108	45	204	71
E	28	14	43	20	81	31	151	47
F	19	9	30	12	56	19	105	27

a Listed data are calculated values based on an equation developed[13] to fit the data given in Reference 3.

b Values greater than 1000 are not realistic because the mixing layer depth (~1000m) can restrict verticle plume growth.

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An evaluation is made of the effectiveness of fixed, real-time monitoring systems around nuclear power stations in determining the magnitude of unmonitored releases. The effects of meteorological conditions on the accuracy with which the magnitude of unmonitored releases is determined and the uncertainties inherent in defining these meteorological conditions are discussed. The number and placement of fixed field detectors in a system is discussed, and the data processing equipment required to convert field detector output data into release rate information is described. Cost data relative to the purchase and installation of specific systems are given, as well as the characteristics and information return for a system purchased at an arbitary cost.

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