NUREG-0673

Answers to Questions About Removing Krypton from the Three Mile Island, Unit 2 Reactor Building

TMI Program Office

Office of
Nuclear Reactor Regulation

U.S. Nuclear Regulatory
Commission

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Washington, D.C. 20555

and

National Technical Information Service
Springfield, Virginia 22161

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May 5, 1980

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PREFACE

This document presents answers to frequently asked questions about removing the krypton from the reactor building of the Three Mile Island Nuclear Station Unit 2 (TMI-2), which was damaged in an accident on March 28, 1979. These answers were prepared by the staff of the TMI-2 Program Office, USNRC, and are based on analyses done by the staff.

The views expressed here are those of the NRC staff. The NRC Commissioners have not yet decided on the method which the TMI-2 licensee, Metropolitan Edison Co., will be permitted to use for removing the krypton from the reactor building.

The purpose of this report is to provide a clear, readily understandable description of the alternative proposals for removing the krypton and the possible impact of each alternative.

More detailed descriptions of the various alternatives being considered, along with the NRC staff's assessment of their effects on the environment, are given in the draft report "Environmental Assessment for Decontamination of the Three Mile Island Unit 2 Reactor Building Atmosphere," NUREG-0662. Two addenda to this report have also been prepared.

NUREG-0662 and Addenda 1 and 2 are available for public inspection at the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C. 20555, and at the TMI-2 Local Public Document Rooms at the Government Publications Section, State Library of Pennsylvania, Education Building, Commonwealth and Walnut Streets, Harrisburg, Pennsylvania 17126, and at York College of Pennsylvania, Country Club Road, York, Pennsylvania 17405. Copies have been circulated for comment to other federal agencies, to the Commonwealth of Pennsylvania, and to local and municipal governments in the Three Mile Island area. Comments on NUREG-0662 and Addenda 1 and 2 are due by May 16, 1980.

Requests for single copies of NUREG-0662 and Addenda 1 and 2 should be addressed in writing to Director, Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. After analysis of the comments, the staff will prepare a final Environmental Assessment and brief the Commission. The Commission will then determine the appropriate action to be taken.

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Q1. Why is it important to go ahead with the cleanup now?

A. The accident has left many unknowns that need to be cleared up about the condition of the reactor and its damaged fuel, about instruments and equipment in the reactor building, and about the condition of the reactor building itself.

Portions of the reactor systems have been underwater for over a year. No one can be certain about the condition of these systems and other vital parts of the plant. Since no significant maintenance work can be done in the reactor building with the krypton present, prolonged delay in removing the krypton may increase the chances for an uncontrolled release of radioactive materials.

Although the extent of fuel damage is not fully known, the fuel will eventually have to be removed for safe disposal. If it is not, there is the remote possibility that the reactor could go critical again (that is, begin to undergo a sustained nuclear reaction). Reactor criticality would have the undesirable effect of producing additional radioactive materials. Some of these materials could escape to the environment. Without access to the reactor building for extended periods, workers cannot remove the fuel. Until the fuel is removed from the reactor, the reactor must be monitored continuously. At present, only one functioning monitor remains. If it fails, there will be no direct means to verify that the reactor is not approaching criticality.

Q2. How do citizens participate in the cleanup decisions?

A. NRC has conducted a broad citizen outreach program in the Harrisburg-Middletown area. People in the area have participated in public meetings with NRC officials and have telephoned their comments and suggestions to the NRC local office in the Middletown Mall. Over 5,000 copies of the NRC Environmental Assessment on the krypton cleanup have been sent to

persons and organizations for comment. These comments will be evaluated and considered in the staff's final recommendation to the Commission. NRC has also been meeting on a continuing basis with local officials to solicit their views.

Q3. How will NRC make its decision about how to remove the krypton?

A. The staff will evaluate all comments received on the draft Environmental Assessment. These comments come from private citizens and groups, local and State officials, and various Federal organizations such as the President's Council on Environmental Quality, the Environmental Protection Agency, and the Department of Energy. The staff will then update the Environmental Assessment and brief the Commission. The Commission will make its decision after this briefing.

Q4. Why does the krypton have to be removed from the reactor building?

A. Workers must enter the reactor building to maintain vital equipment and to eventually remove the damaged fuel. Easier access to the reactor building would permit the gathering of important information needed to plan for the building cleanup. Even with protective clothing, workers would be prohibited from entering the building for extended periods to perform these jobs because of concentrations of radioactive krypton in the building.

Q5. Why does the krypton have to be removed in the near future?

A. Unless the krypton is removed fairly soon, there is some risk that additional accidental releases will occur in the near future. These releases are possible because equipment currently keeping the air pressure in the reactor building lower than air pressure outside of the building has been running almost continuously without maintenance since March 28, 1979. Workers have been prevented from maintaining the equipment that lowers the air pressure because the equipment is located inside of the building.

If this equipment breaks down, the air pressure in the building may rise in relation to outside air pressure. This pressure change could have the effect of forcing the contaminated air in the building to the outside through any opening available. Although the building contains many seals, any number of them may have deteriorated because workers have been unable to get to them to change them. Also, workers cannot replace them without releasing gases.

Q6. Can releases of krypton to the environment be avoided?

A. Probably not. If the krypton gas is not removed soon under controlled conditions, releases could occur accidentally for the reasons specified in the answer to Question 2. All other alternative methods for removing the krypton could involve releases to the atmosphere to varying degrees. The delays associated with putting these alternative methods into operation (a minimum of 1½ years) would increase the likelihood of uncontrolled releases. These releases could take place during weather conditions unfavorable to dispersion of the krypton.

Q7. What is krypton-85?

A. Krypton is a noble gas that does not interact chemically with other chemical elements or compounds. Krypton-85 is a form of krypton that has a half-life of approximately 11 years, which means that one-half of the original amount has undergone radioactive decay to a nonradioactive form of another material in 11 years. This is a continuous process. The radioactive krypton in the reactor building will be essentially decayed to a nonradioactive form in approximately 100 years.

Q8. Where does krypton-85 come from?

A. Krypton is produced when uranium, the power source for a nuclear power plant, splits (fissions) into two or more parts. Krypton-85 is one product of this nuclear fission. In the past, krypton has been released

into the atmosphere during nuclear weapons tests. In addition, krypton has and continues to be released to the atmosphere from nuclear fuel reprocessing plants throughout the world. As a result of these releases, background levels of krypton throughout the earth's atmosphere are readily detectable with suitable instruments.

Q9. How much krypton-85 is presently in the reactor building?

A. Approximately 57,000 curies.

Q10. What is a curie?

A. A curie is the basic unit used to describe the rate or frequency at which any radioactive material emits radiation.

Q11. Will the public be given advance notice if the krypton is released by controlled purging?

A. At least a one-week advance notice would be provided. Releases would be planned according to prevailing weather conditions, so that the timing for advance notice would depend on the weather.

Q12. If this amount is released to the atmosphere by controlled purging, how much will I be exposed to?

A. A person standing outdoors at the site boundary (say near the TMI Observation Center) for three-quarters of the purge period (90 hours) would receive a dose to the exposed skin of 10 millirems and a total body dose of 0.1 millirems. However, since krypton disperses in the atmosphere, concentrations will decrease as it moves away from the site. Persons in Middletown, for example, would be exposed to about 1/18 of the radiation at the site boundary (0.6 millirems to the exposed skin and 0.006 millirems total body), while persons in Harrisburg would be exposed to about 1/200

of that amount (0.05 millirems to the exposed skin and 0.0005 millirems total body).

Q13. What are these exposures equivalent to in terms of chest or dental X-rays?

A. The total body dose to an individual standing at the site boundary would be approximately equivalent to 1% of the dose from one chest or dental X-ray examination. The dose to individuals in Middletown, Goldsboro, or Harrisburg would be considerably less than 1% of the dose from one chest or dental X-ray examination. Looked at another way, someone exposed to the total amount of krypton released would receive less of a dose than residents in the area receive in one day from naturally occurring background radiation.

Q14. Would these exposures cause an increase in cancer in our area?

A. In the collective judgement of nationally recognized radiation protection organizations, there will be no increase in cancer associated with these exposures. Numerically, the chance of one extra case of cancer occurring in the exposed population of 2.1 million people over their remaining lifetime is less than 1 in 1,000. This health effect estimate is based on the recommendations of a number of recognized radiation protection organizations, such as the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurement (NCRP), the National Academy of Sciences Biological Effects of Ionizing Radiation Committee (BEIR), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Each of these organizations in turn collaborates with a number of professional medical and dental associations.

A few radiation specialists have stated that the risks from radiation may be much higher than the risks stated by the above organizations. However, the higher health effects estimated by these individuals have been rejected

by all recognized radiation protection organizations. For example, the latest BEIR report of the National Academy of Science says that there is no evidence that dose rates of 100 millirems per year result in harmful health effects.

Q15. Can krypton-85 accumulate in our bodies?

A. Krypton-85 can accumulate to a small extent in the body, primarily in the fatty tissue. However, it is a short-term condition that reverses itself as soon as krypton concentrations outside the body are reduced to normal background levels.

Q16. Is there a safe level for krypton-85 and who decides what is safe?

A. The International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, and the former U.S. Federal Radiation Council have recommended that annual exposure to krypton-85 as well as other radionuclides should not exceed 500 millirems to the total body and 3,000 millirems to the skin for individual members of the general public. Radiation exposures up to these levels are regarded by the radiation protection organizations identified in the answer to Question 14 as acceptable to ensure public health and safety. (Compare these figures with potential exposures of 0.1 millirems total body and 10 millirems to the exposed skin at the Three Mile Island site boundary during purging.) This determination of safety is based upon the collective opinion of nationally and internationally recognized experts in the field of radiation safety and measurement. Although these limits are considered acceptable, these national and international groups recommend that the exposures be maintained as low as reasonably achievable (ALARA). To this end, NRC determined through a public rulemaking proceeding that reactors are capable of achieving releases that result in small fractions of these safe limits. Accordingly, the annual ALARA dose

design objectives for nuclear power reactors from all sources of radioactive materials are 5 millirems to the total body and 15 millirems to the skin. These objectives apply to the maximum radiation exposure someone could receive at the site boundary during normal plant operations. Doses to persons at distances beyond the site boundary would, of course, be lower.

Q17. Would an accidental release of krypton-85 expose us to these levels of radiation?

A. An accidental release over a short period of time during unfavorable weather conditions could expose the nearby population to a greater dose of radiation than releases from a controlled purge. However, even this somewhat higher dose would be well below NRC radiation exposure limits. All the alternatives to purging listed in the answer to Question 23 require long-term storage of the krypton when it has been removed from the reactor building. Long-term storage, especially for materials stored under any pressure greater than the normal pressure in the atmosphere, also creates the potential for accidental releases. (See Question 29 also.)

Q18. Would NRC monitor in case of an accidental release?

A. Yes. NRC, the Environmental Protection Agency, and the State of Pennsylvania are monitoring the area continuously.

Q19. Would workers at the plant also be exposed?

A. Yes. Total exposure to workers during purging operations would amount to approximately 1.1 person-rems. This exposure, however, would be spread among several Metropolitan Edison employees so that the exposure received by any individual worker would amount to a fraction of the total exposure. NRC regulations require that radiation workers individually be exposed to

no more than 3.0 person-rems over a three-month period and that the total exposure not exceed 5.0 person-rems each year. Thus workers participating in the purge would receive a small fraction of the occupational dose limit specified in NRC regulations to safeguard health.

Q20. What is the purging approach the NRC staff has recommended? What advantages and disadvantages are there to this approach?

A. The NRC staff has recommended releasing the krypton from the reactor building when weather conditions favor dispersion of the krypton into the atmosphere. The advantages to this approach are (1) that releases of the krypton can be controlled so that radiation exposure to the public can be kept as low as reasonably achievable, well within applicable Federal regulations, (2) that no further uncontrolled releases of krypton would occur after purging, and (3) that purging to the atmosphere would eliminate the need for the krypton to be stored and maintained for approximately 100 years, a situation that would be necessary if the krypton were removed by one of the decontamination alternatives under consideration. (See the answer to Question 24.) The disadvantages to this approach are (1) that it would release radioactive krypton to the environment, and (2) that these releases would result in psychological stress to the public. (The table on the next page shows a comparison among the alternative methods.)

Q21. How long would the purging take?

A. Two purging methods are being considered. One would take approximately 30 days over a 60-day period, and the other would take a total of approximately five days over a two-week period. The two-week period would be necessary to allow for changing weather conditions. That is, krypton would be released only when weather conditions were favorable for its dispersion.

COMPARISON AMONG ALTERNATIVE METHODS

	ADVANTAGES	DISADVANTAGES
Purge	• Available Immediately • Eliminates Future Uncontrolled Releases • Eliminates Need For Future Storage & Surveillance • Lower Consequences of Accidental Releases • Familiar Technology	• Psychological Stress • Radiation Exposure to Public (1/10 of 1% of Annual Natural Background Radiation in Harrisburg, Pa.)
Charcoal Adsorption	• Less Radiation Exposure to Public Than From Purging Method • Familiar Technology	• 2- to 4-Year Delay Before Operating • 100-Year Storage and Surveillance of Krypton • Possibility of Krypton Leaks During Storage • Large Volume of Charcoal Required
Gas Compression	• Less Radiation Exposure to Public Than From Purging Method • Familiar Technology	• 2- to 4-Year Delay Before Operating • 100-Year Storage and Surveillance of Krypton Under Pressure • Possibility of Krypton Leaks During Storage
Cryogenic Processing	• Less Radiation Exposure to Public Than From Purging Method • Familiar Technology	• 20- to 30-Month Delay Before Operating • 100-Year Storage and Surveillance of Krypton Under Pressure • Possibility of Krypton Leaks During Storage • Possibility of High Exposures to Workers Compared With Other Methods • Complex System
Selective Absorption	• Less Radiation Exposure to Public Than From Purging Method	• 2- to 4-Year Delay Before Operating • 100-Year Storage and Surveillance Under Pressure • Possibility of Krypton Leaks During Storage • Method Never Used on Large Scale

Q22. Would NRC oversee purging operations?

A. Yes. NRC would have a professional staff at and in the vicinity of Three Mile Island during purging operations. Staff members would be present in the control room for continuous monitoring of weather conditions, the rates at which the reactor building air was being released, and levels of radioactivity in releases.

Q23 Would other NRC staff members come to the Middletown area during purging operations, if the purge is approved?

A. Yes. A number of NRC officials plan to visit the area during actual purging operations, if the purge is approved. They will be accompanied by members of their families in some cases.

Q24. Are there other methods for removing the krypton? What are they?

A. Yes. The NRC staff has evaluated four other possible methods for removing the krypton: (1) charcoal adsorption, (2) gas compression, (3) cryogenic processing, and (4) selective absorption processing.

Q25. What is charcoal adsorption?

A. Charcoal adsorption is a process by which the contaminated air from the reactor building would be piped into large tanks containing charcoal. The krypton would adhere to the surface of the charcoal after coming in contact with it. The charcoal from this process would then be stored for approximately 100 years.

The advantages to this process are that it would expose the general population to less radioactivity than purging the krypton, and the charcoal adsorption method is a well-known technology. The disadvantages are that two to four years would be required to put the process into operation

at Three Mile Island, that the krypton gas would have to be maintained in storage for approximately 100 years, and that the krypton could leak at some time during storage. This process would require such a large volume of charcoal (approximately 34,000 tons) that shipping the contaminated charcoal off Three Mile Island may be impractical.

Q26. What is the gas compression process?

A. Gas compression is a process by which the air containing the krypton gas in the reactor building would be drawn off into pressurized storage containers. These pressurized containers would then have to be stored in approximately 28 miles of piping. The advantages of this process are that it would expose the general population to less radioactivity than purging the krypton, and gas compression is a known technology. The disadvantages are that two to four years would be required to put the system into operation, that the krypton gas would have to be maintained under pressure in storage in many pressurized containers for approximately 100 years, and that the krypton could leak at some time during storage.

Q27. What is cryogenic processing?

A. Cryogenic processing is a method of removing krypton from the reactor building air by liquifying the krypton gas as it comes in contact with liquid nitrogen. The liquid krypton would then be turned into a vapor and compressed into containers for extended storage. The advantages to this process are that it would expose the general population to less radioactivity than purging the krypton, and cryogenic processing is a known technology. The disadvantages are that a 20- to 30-month delay would be necessary before the process could be put into operation at Three Mile Island, that the krypton gas would have to be maintained under pressure in storage for approximately 100 years, and that the krypton could leak at some time during storage. Operating and maintaining the cryogenic processing system, and storing the pressurized gas for

approximately 100 years would result in high occupational exposures compared with the other alternatives.

Q28. What is the selective absorption process?

A. The selective absorption process would withdraw all the air in the reactor building, separate from it essentially all the krypton, and return the decontaminated air to the reactor building. The contaminated air would pass through a column in which liquid Freon would absorb the krypton while allowing the other gases to pass through unchanged. Once separated, the krypton could be stored for approximately 100 years under high pressure in gas cylinders. The advantage to this process is that it would expose the general population to less radioactivity than purging the krypton. The disadvantages are that two to four years would be required before this process could be put into operation at Three Mile Island, that the krypton gas would have to be maintained under pressure in storage for approximately 100 years, and that the krypton could leak at some time during storage. This method is still experimental and has never been used commercially on a large scale.

Q29. Is it possible to dispose of the krypton from the gas compression, cryogenic, and selective absorption processes other than by storing it for approximately 100 years?

A. Krypton from these processes could possibly be transported to and released in a remote, uninhabitated area. However, releasing the krypton, even in a remote area, would add slightly to the total accumulation of krypton in the earth's atmosphere and would, as a result, contribute a small amount of radiation exposure to the world's population. (See the answer to Question 40.)

Q30. Why is the NRC staff recommending that these processes not be used?

A. Each of the alternative methods for removing the krypton, except for purging, would take at least 1½ years to put in working order at Three Mile Island. Each system would require extensive design, testing, and onsite construction work. For these reasons, and for the reasons specified in the answers to Questions 1, 4, and 5, the NRC staff believes that the krypton should be purged from the reactor building as soon as possible.

Q31. Would weather affect the rate at which the krypton is released?

A. Yes. The rate at which the krypton would be released would depend on two things: (1) favorable weather conditions, and (2) concentrations of krypton within the reactor building. Moderate to strong winds would favor good dispersion of the krypton. The purge would begin gradually because of relatively high krypton concentrations at the outset. As fresh air was drawn into the reactor building to dilute the krypton concentrations, the rate at which the reactor building atmosphere was purged could be increased. Weather data gathered before and during purging periods would be used to ensure that offsite radiological exposures were kept as low as reasonably achievable, and well below appropriate Federal requirements.

Q32. What is the best time of year for favorable weather conditions?

A. Extended periods of moderate to strong winds are most likely to occur from March through May.

Q33. What would happen to the krypton after its release from the reactor building?

A. Krypton would disperse outward from the plant according to the speed and direction of prevailing winds and other atmospheric conditions. Smaller and smaller concentrations would be present in the air as its distance from the plant increased. All the krypton released would eventually disperse nearly uniformly throughout the Northern hemisphere and remain in the upper atmosphere until it all decayed.

Q34. Would the air in the reactor building be filtered before it is released?

A. The air would pass through several special, highly efficient filter systems before being released to the atmosphere.

Q35. Would these filters remove the krypton?

A. No.

Q36. Why?

A. Although the filters are capable of removing 99.9% of the particles in the air, they cannot trap gases like krypton because these gases do not chemically combine with other materials. The filters, therefore, would not be effective in removing the krypton. The filters would of course remove any dust or other particles in the reactor building air before its release to the outside atmosphere.

Q37. What organizations would monitor these releases?

A. Releases around Three Mile Island would be monitored by the following organizations:

the Environmental Protection Agency,
the Department of Energy,
the Nuclear Regulatory Commission,
the Commonwealth of Pennsylvania, and
Metropolitan Edison Company.

The Department of Energy (DOE), through the Commonwealth of Pennsylvania, is offering citizens near Three Mile Island training to enable them to participate in monitoring radioactivity levels during purging operations. DOE would also make available its meteorological predicting resources during purging operations.

Q38. How far from the site would monitoring be conducted?

A. The Environmental Protection Agency (EPA) would monitor for radioactivity out to 7 miles from Three Mile Island and would position air-sampling stations and other devices considerably beyond that. Monitoring devices beyond 7 miles would be used to verify predictions that concentrations of krypton-85 at these locations would be so low as to be essentially undetectable. The State of Pennsylvania has monitors still further away - in Harrisburg. In addition, the EPA has two mobile monitoring teams that would be moved to locations for which the highest levels of radiation are predicted to occur.

Q39. Would the results of this monitoring for krypton be made available to the public?

A. Yes. If krypton were released in a controlled purge, the EPA would provide the results of its monitoring program to the public daily. At present, EPA provides its monitoring results to the press and public three times a week. This information is being disseminated by local news media.

Q40. Should I be concerned about this krypton-85 being added to the earth's atmosphere?

A. No. The present amount of krypton in the earth's atmosphere is roughly 20,000,000 curies. (See the answer to Question 8.) Releasing all 57,000 curies of krypton from the reactor building would increase the

total amount of krypton in the atmosphere by less than a quarter of one percent (0.25%). The total krypton in the earth's atmosphere makes a very minor contribution to human radiation exposure. Krypton makes up a small fraction of the radioactivity in the atmosphere from all sources.

Q41. Could the krypton gas from the reactor building settle in low places?

A. The krypton in the reactor building is very dilute. Otherwise, it would have settled to the bottom of the reactor building, which it has not done. Moreover, the krypton would be released only during weather conditions that favored good dispersion in the atmosphere. Should weather conditions become unfavorable, the releases would be stopped. Krypton would not settle in house basements.

Q42. Would other radioactive materials be released from the reactor building with the krypton?

A. Small amounts of tritium, a radioactive form of hydrogen, would be released when the reactor building is purged because tritium is a radioactive material in the contaminated water and humid atmosphere in the reactor building. In addition, extremely small amounts of radioactive particles may pass through the high-efficiency filters and be released to the atmosphere. The exposure from tritium and other radioactive materials being released would be much lower than exposures from krypton.

Q43. What is the best method for removing the krypton from the reactor building quickly?

A. Purging the reactor building offers the best method for removing the krypton quickly because of the time that would be required to design, test, and install alternative krypton-removal systems. Purging, which can also be controlled so that releases are made only during weather conditions that favor good dispersion, is an environmentally acceptable

means of permanently disposing of the krypton. All the alternatives require that the krypton be stored in containers that could leak and thus pose a future hazard.

NRC FORM 335 (7-77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER *(Assigned by DDC)*

NUREG-0673

4. TITLE AND SUBTITLE *(Add Volume No., if appropriate)*

Answers to Questions about Removing the Krypton from the Three Mile Island Unit 2 Reactor Building

2. *(Leave blank)*

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S)

5. DATE REPORT COMPLETED

MONTH	YEAR
May	1980

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*

Three Mile Island Program Office
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

DATE REPORT ISSUED

MONTH	YEAR
May	1980

6. *(Leave blank)*

8. *(Leave blank)*

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.

13. TYPE OF REPORT

Public Information

PERIOD COVERED *(Inclusive dates)*

15. SUPPLEMENTARY NOTES

14. *(Leave blank)*

16. ABSTRACT *(200 words or less)*

This document presents answers to frequently asked questions about the probable effects of controlled releases of the krypton presently contained within the reactor building of Three Mile Island, Unit 2. Also answered are questions about alternative means for removing the krypton.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT

19. SECURITY CLASS *(This report)*

20. SECURITY CLASS *(This page)*

21. NO. OF PAGES

22. PRICE
$

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. NUCLEAR REGULATORY
COMMISSION

U.S. MAIL