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Final Environmental Assessment for Decontamination of the Three Mile Island Unit 2 Reactor Building Atmosphere

Final NRC Staff Report

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TMI Support Staff
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

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TABLE OF CONTENTS

PREFACE

This Final Environmental Assessment revices the draft Environmental Assessment issued for public comment in March 1980. Revisions to the draft Assessment have been made in response to comments received and to additional reviews and analyses conducted by the NRC staff.

The Nuclear Regulatory Commission has not yet made a decision on the disposition of the krypton-85 gas in the reactor building atmosphere at TMI Unit 2. The views and recommendations expressed here are those of the Commission staff.

This report was prepared by the staff of the Three Mile Island Program Office, Office of Nuclear Reactor Regulation, with the assistance of additional staff members from within NRC.

Dr. Bernard J. Snyder, Program Director
Three Mile Island Program Office
U.S. Nuclear Regulatory Commission
Washington, DC 20555

1.0 Summary and Recommendation

The NRC staff has prepared this summary of the Final Environmental Assessment for those who prefer to follow the main themes of the assessment without referring to the technical descriptions, calculations, and other data that provide the foundation upon which the staff's recommendation is based.

The krypton-85 (Kr-85) released into the reactor building during the accident on March 28, 1979, must be removed from the building so that workers can begin the tasks necessary to clean the building, maintain instruments and equipment, and eventually remove the damaged fuel from the reactor core. Those tasks must be performed whether or not the plant ever again produces electricity. Radiation from the krypton gas, although thinly dispersed through the reactor building atmosphere, nevertheless poses a threat to workers who would have to work in the building for prolonged periods.

This Final Environmental Assessment (NUREG-0662) presents a discussion of the information considered by the NRC staff in arriving at its recommendation that the preferred method for removing the krypton-85 from the reactor building is by a kind of flushing process by which the gases would be pushed out of the building and fresh air pulled in.

The Metropolitan Edison Company (the licensee) on November 13, 1979, asked the NRC staff for permission to purge or remove the reactor building atmosphere containing the krypton-85 to the outside (Ref. 1). In March 1980, the NRC staff published the draft version of this Environmental Assessment (NUREG-0662) and two subsequent Addenda for public comment (Ref. 2). The staff has received approximately 800 comments on the draft Environmental Assessment. Of these, approximately 195 responses generally supported the purging of the reactor building, approximately 500 opposed it, and the remaining responses were either recommended alternatives for removing the krypton or comments that took no position on the staff's recommendation. Substantive comments received by the NRC staff will be printed in Volume 2 of this Assessment.

From this process have emerged some NRC staff conclusions on four basic aspects of dealing with the reactor building atmosphere:

---The potential physical health impact on the public of using <u>any</u> of the proposed strategies for getting rid of the krypton-85 is negligible.

---The potential psychological impact is likely to grow the longer it takes to reach a decision, get started, and complete the process.

---The purging method is the quickest and the safest for the workers on Three Mile Island to accomplish.

---Overall, no significant environmental impact would result from use of any of the alternatives discussed in this Assessment.

The Problem

As will be developed in the following discussion, decontamination of the reactor building atmosphere at this time is a necessary activity irrespective of whether subsequent cleanup operations are authorized or of the nature of such operations. There presently exists a need for relatively prolonged access to the reactor building for purposes of maintenance of equipment essential for continuation of the safe shutdown mode and for data gathering activities so that the nature and extent of future cleanup measures can be determined. In addition, it is believed that the prompt initiation of decontamination will be beneficial from the standpoint of alleviating some of the psychological stress now being experienced by the nearby public.

Furthermore, authorization of any of the alternative methods for decontaminating the reactor building atmosphere, being an action independent of any subsequent cleanup activities, does not foreclose, nor predetermine, the consideration or selection of any alternative to such subsequent measure.

Taking the foregoing into consideration, the staff believes that it is in the best interest of the public health and safety to authorize this activity at this time, prior to issuance of the Programmatic Environmental Impact Statement, now in preparation.

The March 28, 1979 accident in Three Mile Island Unit 2 heavily damaged the uranium fuel in the core of the reactor. Many radioactive substances that normally remain trapped in the fuel rods were released when the fuel rods were themselves broken. Some of the radioactivity, in the form of gases, leaked out of the reactor system, along with a large amount of water. Some of the gases escaped to the environment and some of the water reached other parts of the plant before being captured. A great deal of water and a substantial amount of radioactive gases remained confined in the reactor building.

As long as the damaged fuel in the reactor core is cooled and remains relatively undisturbed and surrounded by boron, there is essentially no chance that the fuel chain reaction, which was abruptly stopped by the accident, could start again. But as time passes, the NRC staff believes that there will be an increasing chance of essential equipment wearing out or malfunctioning. If the core were accidentally to begin to undergo a chain reaction once more, it could cause releases of more radioactivity within the reactor building. Therefore, removal of the damaged fuel for safe storage is the paramount objective of the cleanup of TMI-2.

Shortly after the accident, the radioactive gases xenon and iodine accounted for most of the radioactivity in the reactor building atmosphere. But because these gases decayed to nonradioactive forms rapidly, they now account for only about one millionth of the radioactivity in the building air. Nearly all of the radoactivity now in that air comes from the relatively longer-lived krypton. Traces of a radioactive form of hydrogen, called tritium, are in the building atmosphere at levels 10,000 times lower than the krypton. Most of the radiation given off by krypton-85 in the reactor building is a kind that can be blocked by heavy layers of clothing (which could also severely hamper workers). However, it is not this "beta" radiation that is of primary concern for worker health. The primary concern is with the more penetrating gamma radiation. Since krypton-85 contributes significantly to the gamma dose within the reactor building (it accounts for as much as 75% of the total in some areas of the building), removal of the krypton is necessary. Even with the krypton-85 removed, there would still be radiation from the damaged reactor core, from radioactive material deposited on surface, and from the more than seven feet of contaminated water in the basement of the building. But, the radiation dose rate for workers would be cut from about 2.3 rem per hour to 1.6 rem per hour at the 305-foot level in the building, and from about 1.3 to 0.3 at the 347-foot level if the krypton-85 were removed from the building.

At the present time, the reactor building is sufficiently air-tight so that steady cooling of the air in the building has kept its pressure at slightly below outside air pressure. Whatever small air leakage there has been has come in from the outside, rather than to the outside. However, the cooling system fans, designed to run continuously for only a few hours, have been running for more than a year, and they may fail over a period of time. If they do, a rise in pressure inside the reactor building would lead to small puffs of uncontrolled leakage of the building atmosphere to the outside. This would not pose a health hazard to the public but would be of major concern and could contribute to anxiety among residents in the area. Controlled and monitored removal of the building atmosphere before the cooling fans fail would avert that possibility.

The Proposed Solution

In performing its Environmental Assessment of Metropolitan Edison's proposal to purge the reactor building atmosphere, the NRC staff has not only evaluated that plan but also has evaluated several alternatives, including the following:

1. No action.

2. Purging (Slow or Fast, Lower or Higher Release Points).

3. Selective Absorption Process.

4. Charcoal Adsorption, Including a Refrigerated Adsorber System.

5. Gas Compression and storage.

6. Cryogenic Processing (Liquifying the Gas and Storing for Later Disposal).

7. A Combination of Purging and the Other Alternatives.

1. No Action

Leaving the contaminated air in the reactor building indefinitely would leave one important phase of the cleanup process undone. It would also carry other risks. First, it would be physically more difficult, if not impractical, for workers to do any significant cleanup work in the building because of the heavy protective clothing and air-supply equipment they would be required to wear. Under these conditions, workers may be limited to only 15-30 minutes in the building before air supplies must be replaced. Dose considerations would also limit the "stay time" of workers in the building. Second, to the extent that it would interfere with maintainance of already over-used equipment in the building, indefinite delay might cause failure of equipment essential to keeping the damaged reactor core in a safe condition. Third, the building could begin to leak unexpectedly. Although the leakage is not considered a significant threat to the health and safety of the public, it could generate the same anxiety and stress that similar minor leakage incidents at the plant have generated in the past.

2. Purging

The TMI-2 reactor building has two separate systems that can be used to move air from the inside of the building to the outside by way of filtering and monitoring equipment leading to a ventilation stack that reaches 160 feet in the air. The smaller of the two systems was designed as a backup system to the hydrogen recombiner system to reduce hydrogen concentrations in the building following a loss-of-coolant accident so as to prevent possible gas explosions. This hydrogen control subsystem, when modified, would employ a fan with the capacity to move up to 1,000 cubic feet of air per minute. This fan would be started slowly and run at low rates until the krypton-85 concentrations in the building had been lowered by dilution with fresh air so that larger volumes could be sent outside without raising the concentrations of radioactivity around the site. If this system of fans and ducts was used by itself, it would take about 30 days of actual purging, spread over about a 60-day period, to complete the purging operation. The larger of the reactor building purge systems is the building's ventilation system. If this larger system were used along wth the hydrogen control subsystem, both systems could remove the required amount of air in about five days of actual purging, during good weather, over a 14-day period. Both the hydrogen control subsystem and the reactor building purge systems are equipped with control valves and **their** own trains of filters so that fine particulate radioactive material would be removed from the air before it is discharged to the outside through the ventilation stack. Just before reaching the stack, the air from the reactor building would be mixed with air from other plant buildings to provide some dilution before it is discharged from the stack. As the air bearing the krypton-85 is pulled out of the reactor building, fresh air from the outside would enter the building through an open valve.

The staff also examined the possibility of extending the 160-foot high stack to 400 feet with piping supported by scaffolding or guy wires. The staff believes that under the best of weather conditions elevating the stack could reduce the maximum possible exposures closest to the site to as little as 1/8th the dose predicted to occur for the 160-foot stack. The staff has estimated that designing, construction, and leak testing the added stack section would delay cleanup of TMI-2 by about four to five months.

The staff next considered construction of a new 1000-foot stack to provide additional altitude for releasing the reactor building air. The staff estimated that it would take at least 11 months to design, build, and test such a stack to adequate safety criteria. They also felt that while the higher stack would reduce the public's radiation exposure, the projected exposure was already so low as to pose no radiological health hazards and that the minimum of an 11-month delay to build a stack of 1000 feet could not be justified. Finally, the staff evaluated two proposals submitted by the Union of Concerned Scientists to Governor Thornburgh (Ref. 3). The first proposal was that the reactor building air be heated to give it more buoyancy upon its release from the stack for more effective rise and dispersal.

The NRC staff believes that although heating of the discharge would reduce the public's radiation exposure somewhat, the UCS has underestimated the time it would take to put such an incinerator-heating system into operation, and that instead of the seven to nine months predicted by the UCS, it would take a minimum of 9 months. (The UCS estimated construction time only, excluding design, engineering, procurement, and testing of the incinerator scheme.) The staff said the expected dose reduction of a factor of about 30 to an individual and the delay do not justify the impact of delaying the cleanup operation.

The second proposal was that a 2000-foot tube of reinforced fabric, held aloft by a tethered balloon, be used as a stack for discharge of the reactor building air. Because the method is unique and untried, the staff said there was some uncertainty as to how long it would take to implement, but the staff thought it could work. The staff thought it would take 7 to 10 months to design, build, and test such a system. However, the staff felt that the psychological impact of a balloon clearly visible over the site may offset any advantage which might be gained by a reduction of the dose to any individual.

3. Selective Absorption

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 either high pressure in a few gas cylinders, or under low pressure in a larger number of cylinders.

The Union Carbide Company of Oak Ridge, Tennessee, has been developing a selective absorption process since 1967. Their latest small-scale pilot plant, in operation since 1978, can remove 99.9% of the krypton passed through it. Union Carbide officials are optimistic that a larger version of this pilot plant (scaled up at least 10 times) can work at Three Mile Island. Estimated times for completing this larger version vary. Oak Ridge personnel estimate that a system could be put in service at TMI in 10 months. To construct the system in this period would require a crash program that would use standard industrial design criteria, off-the-shelf components, and no competitive bidding. This estimate does not consider the need for a suitable building at the TMI si*e and is based on other questionable assumptions.

In the best judgment of NRC construction experts, the shortest possible time to design, procure, construct and test a suitable selective absorbtion system is 16 months. This time period is considered by the staff to be an undesirable delay in getting the cleanup of the reactor building initiated It is relevant to note that the Oak Ridge National Laboratory, the organizaton most knowledgable about the selective absorption system, has recommended against using that system and favors controlled purging to dispose of the krypton gas.

4. Charcoal Adsorption

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 isolated and stored.

The NRC staff evaluated both normal temperature and refrigerated charcoal adsorber systems. Both systems require large quantities of charcoal; the first 34,000 tons and the second 12,000 tons. During normal operation, no releases of radioactivity would be expected. Since noble gases do not react chemically with charcoal, but just stick to its surface, long-term surveillance would be required during storage. The krypton-bearing charcoal would have to be stored (and watched over) for up to 100 years to allow the radioactivity to decay to insignificant levels.

The staff's major concern was the environmental impact of long-term onsite storage, and the long delay caused by construction of the charcoal system. Construction and testing of a charcoal system would delay by from two to four years the containment atmosphere cleanup. The staff considers this to be an intolerable delay in the overall cleanup effort.

5. Gas Compression

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 be stored in sealed sections of piping. For example, at a pressure of 300 pounds per square inch, about one million cubic feet of pipe, 36 inches in diameter would be required. This corresponds to about 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 and is a known technology. The disadvantages are that two to four years would be required to put the system into operation, the krypton gas would have to be maintained under pressure in storage in many pressurized containers for approximately 100 years, and the krypton could leak at some time during storage. The staff has concluded that this alternative is impractical.

6. Cryogenic Processing

Cryogenic processing is the condensation of krypton-85 from the incoming air by bringing it into direct contact with liquid nitrogen (-320°F). The liquified krypton-85 is collected, restored to a gas form, and stored to allow decay. An alternative to storing would be to transport the containers of the separated krypton (whether from the cryogenic or selective absorption systems) to a burial ground or to a remote area and release the krypton gas to the environment.

The NRC has looked at several cryogenic systems available from commercial nuclear power plants. None of these systems has been operated successfully. Although these new systems could be purchased, a new building would be required to house the system and contain any possible leakage. The cryogenic system would be connnected to the piping of the existing hydrogen control system. The air from the reactor building would be passed through the filters and charcoal adsorber of the hydrogen control system and then piped to the cryogenic processing system in the adjacent building. At least 20 months are estimated to be required to obtain a fully operational cryogenic system at the TMI site. This estimate is based on NRC staff assessments and consultations with construction engineers at Oak Ridge National Laboratory.

During the approximately 2-½-month period required to process the reactor builidng atmosphere, about 60 curies of krypton-85 would be released to the environment with the purified effluent from the system. Also, some leakage from the system is anticipated, but the staff believes this can be minimized by judicious monitoring and a rapid system shutdown if trouble develops. However, based on limited experience with these systems, operation and maintenance are likely to result in a relatively high occupational dose. Designs have been proposed to store the radioactive krypton on the site while it decays. This will require surveillance for 100 years and represents a continuing risk to workers at the site, as well as a potential source of anxiety to the public. Alternatively, burial or release of the contaminated krypton at a remote site could be accomplished. However, the NRC staff believes that release in a remote area probably would not be acceptable to local officials and residents.

7. Combined Processes

The staff evaluated combinations of various alternatives, using one of the krypton extraction and recovery systems, such as charcoal adsorption, gas compression, cryogenic, or selective absorption for most of the krypton, and purging the rest to the environment. One of the krypton recovery systems would trap about 95% of the krypton (54,000 curies) and the other 5% (3,000 curies) could be released to the environment. The size of the processing system or the size of the storage facility for the final material holding the krypton would be only about 25% to 33% of what would be needed if there were no purging used at all. Of all the combinations considered by the staff, those using smaller size cryogenic processing or selective absorption could be built the fastest but even so would take at least one year to be operational. Additional time would then be required to complete the processing and final purging. The staff still considers this an unacceptable delay in the overall decontamination of the reactor building atmosphere.

Onsite Long-Term Storage of Krypton-85

With the exception of direct controlled purging of the reactor building to the outside, all the proposed processes leave the radioactive krypton to be stored onsite, in some form, for about a century. If a leak were detected in an above-ground storage facility at the site, actions could be taken to terminate the leak by transferring the contents of the leaking container to a new one. The staff believes that more study is needed in the selection of materials for such storage containers, and in their fabrication, because of the possibility that containers may corrode over the projected 100 years it will take the krypton radioactivity to decay away.

Transportation and Offsite Disposal

Alternatively, the krypton gas would be appropriately packaged and transported to a waste burial facility for burial or taken to a remote location, such as a desert, and released to the environment. The NRC staff estimates that the impact of handling, packaging, transportation and burial or remote release of the Kr-85 would be 8-24 person-rem (total body).

Public Health and Environmental Effects

Physical Effects

The NRC staff has determined that there are negligible physical public health risks associated with the use of any of the alternatives (excepting the "no action" alternative). For the venting alternative in particular, in independent analyses, the National Council on Radiation Protection and Measurements, the U.S. Environmental Protection Agency, the U.S Department of Health, Education, and Welfare, and the Union of Concerned Scientists have reached the same conclusion. Additionally it should be noted that, based on the relatively greater radiosensitivity of humans, purging would have no adverse impact on plants or animals.

An estimate of the total number of fatal cancers, resulting from purging and the other alternatives, has been made by the NRC staff. The total potential cancer deaths for both the 50-mile population surrounding TMI-2 and plant workers is estimated to range from a minimum of 0.0003 (purge option) to a maximum of 0.034 (cryogenic option). Almost all of this small risk would be borne by workers exposed at the plant (purge = 0.0002, cryogenic = 0.034). The total fatal cancer risk among all people within 50 miles of TMI from purging would be about 0.0001. This corresponds to an average risk of 0.000000000045 to each of 2,200,000 individuals living within 50 miles of the plant, i.e., about 5 chances in 100 billion.

The total risk of some type of genetic abnormality, resulting from the decontamination alternatives, to the public within 50 miles and plant workers has also been estimated. This genetic risk has been estimated to range from a minimum of 0.0005 effects (purge option) to a maximum of 0.066 effects (cryogenic option). Again, almost all the risk would be borne by workers (and their descendants) at the plant (purge, 0.0003 effects; cryogenic 0.066 effects. The maximum genetic risk to any offsite member of the public from the various options would be 5 chances in 100 million (0.000000005), compared to the current expectation of all kinds of normally occuring genetic effects of one million to five million in 100 million (0.01 to 0.05).

Finally, the NRC staff has estimated risks associated with development of skin cancer. As a result of purging, a skin dose of 11 mrem (see Table 1.1) to the maximum exposed individual, is estimated to result in a risk of death of about one chance in a billion (0.000000001). A population skin dose of 63 person-rem (purge option) would be estimated to cause considerably less than one (about 0.000006) additional skin cancer deaths among the 50-mile population of 2.2 million people. This compared with about 4,000 deaths from skin cancer (from other causes, primarily sunlight), which would normally be expected in the 50-mile population (assuming 75 years life expectancy) around TMI. Other risk comparisons are provided in Tables 7.2 and 7.3.

Psychological Stress

The various alternatives for decontamination of the TMI-2 reactor building atmosphere are expected by the NRC staff to have different psychological impacts.

The NRC staff, with the assistance of consulting psychologists from the Human Design Group, has compared these to what already has been found by some studies of the psychological stress effects of the TMI accident. Previous research suggests that an event like the accident at TMI-2 produces two types of stress: short and continuing. Short-term effects or those directly related to the occurrence of the incident are reported to be intense but short-lived. Some researchers have reported that while stress-related indicators were high shortly after the accident, they had dissipated by mid-summer of 1979. Their findings suggest that stress changes with time, and that long-term mental health implications may be less than previously thought.

Based on consultations with psychologists, the staff has concluded that the purging alternative, which can be implemented promptly, has less potential for creating long-term psychological stress than those alternatives which take longer to complete. Furthermore, since a prompt decision on, and completion of, purging will be the first major step toward eventual cleanup of the reactor building and decontamination of the site, it is anticipated that a majority of the public will perceive this action as leading to elimination of future risks from TMI-2. The NRC staff, based on advice received from its consulting psychologists, believes that this public perception will reduce the stress and anxiety of the public.

Radiological Environmental Monitoring Program

The radiological environmental monitoring around the TMI site and nearby communities during decontamination of the reactor building atmosphere would be performed by (1) the U.S. Environmental Protection Agency, (2) the Commonwealth of Pennsylvania, (3) the U.S. Department of Energy, (4) the Nuclear Regulatory Commission, and (5) Metropolitan Edison Company (the licensee),

The EPA is the lead agency for the Federal government in monitoring the area surrounding Three Mile Island. EPA operates a network of eighteen air monitoring stations ranging from one-half to seven miles from TMI. EPA will also use a number of mobile radiation monitoring vehicles positioned in the predicted downwind trajectory during purging. EPA will issue daily reports of their measurements to the public during the purging of krypton.

In addition to their own direct monitoring, the Department of Energy and Commonwealth of Pennsylvania are sponsoring a Community Radiation Monitoring Program that involve people from 12 communities in an approximate 5-mile circle around TMI.

About 50 individuals have completed training classes conducted by the Nuclear Engineering Department of Pennsylvania State University. The classes involved classroom instructions, laboratory training, and actual radiation monitoring in the field. The teams will use EPA gamma-rate recording devices, which are currently in place around TMI, and which will be supplemented by gamma/beta sensitive devices being furnished by DOE through EG&G Idaho, Inc.

The training sessions were designed to provide a working knowledge of radiation, its effects, and detection techniques, and included hands-on experience with monitoring equipment in the field. Citizens will be expected to demonstrate minimal competence in radiation monitoring before actual monitoring efforts begin. Following the completion of training, team representatives in each of 12 selected areas have been gathering and reporting data from the gamma and gamma/beta-sensitive instruments on a routine basis.

Response to Comments

The draft "Environmental Assessment for Decontamination of the Three Mile Island Unit 2 Reactor Building Atmosphere" (NUREG-0662) and two subsequent addenda were issued for public comments late in March 1980. The public comment period ended May 16. Approximately 800 responses have been received, each of which fell into one of three categories: (1) those supporting the purging alternative recommended by the NRC staff (approximately 195 responses), (2) those opposed to the purging alternative (approximately 500 responses), and (3) those who recommend decontamination alternatives other than those discussed in the Environmental Assessment or who otherwise commented on the assessment (approximately 105 responses). Section 9 of this report provides the NRC staff's response to these comments.

Copies of correspondence received are available for inspection and copying for a fee at the NRC Public Document Room at 1717 H Street, NW, Washington, D.C. 10555, and at the NRC Local Public Document Rooms, State Library of Pennsylvania, Government Publications Section, Education Building, Commonwealth and Walnut Street, Harrisburg, PA 17126, and York College of Pennsylvania, Country Club Road, York Pennsylvania 17405. All substantive comments received will be published in Volume 2 of this final assessment.

Public Information Activities

In an effort to better inform the public in the area around Three Mile Island about the contents of the draft Environmental Assessment (NUREG-0662, and Addenda 1 and 2), NRC has conducted a series of 38 informational meetings and activities. The staff also issued an easy-to-understand report that answers frequently asked questions about removing the krypton from the reactor building. Copies of the report, "Answers to Questions about Removing Krypton from the Three Mile Island Unit 2 Reactor Building" (NUREG-0673), are available free of charge by writing to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Most of the meetings held were planned by the NRC, although some were organized by other interested groups, at which NRC officials were invited participants. Members of the U.S. Environmental Protection Agency and the Pennsylvania Department of Environmental Resources (DER) were usually invited participants at these meetings. EPA officials outlined their agency's program and responsibilities for environmental monitoring in the vicinity of the TMI site, while State DER personnel explained the community monitoring program and other state functions related to the clean-up of TMI Unit 2. At these meetings, NRC officials expressed their willingness to meet with other groups of people who had an interest in receiving additional information on the Environmental Assessment or clean-up operations at Unit 2.

Table 1.1

Environmental Impacts of Alternatives for Removing the Krypton-85 from the Reactor-Building Atmosphere

Method	Total Offsite Dose to Maximum Exposed Individual* — Normal Processing	Accidents	Occupational Exposures
Reactor Building Slow Purge	Beta skin dose - 11 mrem Total body gamma dose - 0.2 mrem	Beta skin dose - 25 mrem Total body gamma dose - 0.3 mrem	1.2 person-rem
Reactor Building Fast Purge	Same as above	Same as above	Same as above
Elevated (400 ft.) Purge	Approximately 1/8 (0.13) of Slow Purge above	Same as above	Same as above
Elevated (1000 ft.) Purge	Approximately 1/230 (0.004) of Slow Purge above	Same as above	Same as above
Hot Plume (250 ft.) Purge	Approximately 1/30 (0.003) of Slow Purge above	Same as above	Same as above
Balloon/Tube (2000 ft.) Purge	Approximately 1/300 (0.003) of Slow Purge above	Same as above	Same as above
Selective Absorption Process System	Less than Cryogenic Processing System	Absorption Process Beta skin dose - 6 mrem Total body gamma dose - 0.1 mrem Gas Storage Beta skin dose - 1700 mrem Total body gamma dose - 20 mrem	115-220 person-rem
Charcoal Adsorption Systems	Less than Cryogenic Processing System	Ambient Charcoal System Beta skin dose - 41 mrem Total body gamma dose - 0.5 mrem Refrigerated Charcoal System Beta skin dose - 124 mrem Total body gamma dose - 1.5 mrem	47 person-rem

Table 1.1 (Continued)

Total Offsite Dose to Maximum Exposed Individual*

Method	Normal Processing	Accidents	Occupational Exposures
Gas Compression System	Less than Cryogenic Processing System	Beta skin dose - 410 mrem Total body gamma dose - 5 mrem	41 person-rem
Cryogenic Processing System	Beta skin dose - 0.01 mrem Total Body Gamma dose - less than 0.0002 mrem	Beta skin dose - 1700 mrem Total body gamma dose - 20 mrem	157-255 person-rem
Combination Process/ Purge	Approximately 1/95 (0.01) of Slow Purge above	Beta skin dose - 1700 mrem Total body gamma dose - 20 mrem	115-255 person-rem
No Action	Beta skin dose - 0.01 mrem Total body gamma dose - less than 0.0002 mrem	(The potential offsite and occupational dose from the extremely large inventory of radioactive material within the reactor building cannot be reliably estimated for long periods of containment, but is potentially high and could exceed other alternatives considered.)	

*The collective 50-mile offsite population doses resulting from the purging alternatives are estimated to be 0.76 and 63 person-rem for total-body and skin doses respectively. Although elevating the release point would reduce these population dose estimates, the reduction would probably be no greater than 10%.

2.0 Proposed Action

The action proposed is to purge from the reactor building at Three Mile Island, Unit 2, the krypton-85 released from the damaged fuel as a result of the accident on March 28, 1979. This NRC staff Final Environmental Assessment responds to a proposal submitted by Metropolitan Edison Company (the licensee) for purging the reactor building atmosphere through the building's existing hydrogen control subsystem (Ref. 1). This Assessment does not address decontamination of reactor building equipment, interior walls and surfaces, and treatment and disposition of water in the reactor building sump or in the reactor coolant system. These issues will be addressed in a Programmatic Environmental Impact Statement to be issued by the NRC staff later in 1980.

3.0 Introduction

As a result of the March 28, 1979 accident at the TMI Unit 2 facility, significant quantities of radioactive fission products and particulates were released into the enclosed reactor building atmosphere because of substantial fuel failure in the reactor core. At the present time, the dominant radionuclide remaining in the reactor building atmosphere is krypton-85 (Kr-85), which has a 10.7-year half-life. Based on periodic sampling of the reactor building atmosphere since the accident, the concentration of the Kr-85 in the building is about 1.0 μCi/cc, yielding a total inventory of approximately 57,000 curies. Reactor building atmosphere sampling and analysis are discussed in detail in Section 4.0.

At the present time the reactor is safely shut down, and is being maintained that way with the damaged fuel in the reactor vessel. Reactor building air-cooling equipment is maintaining the building at a slightly negative pressure (approximately -0.7 psig) with respect to the outside atmosphere. This pressure differential ensures essentially no leakage of the reactor building atmosphere to the environment. However, before the facility can be considered to pose no threat to public health and safety, the damaged fuel must be removed from the reactor vessel and building, placed in containers if necessary, and safely stored. The radiation levels in the reactor building are currently such that occupancy is severely restricted. Less restricted access to the reactor building is required to facilitate the gathering of data needed for planning the building decontamination program, and for the subsequent work required to accomplish decontamination and other cleanup operations. Less restricted occupancy will require that the building atmosphere be decontaminated to protect workers from exposure to the beta and gamma radiation associated with the Kr-85 in the reactor building atmosphere.

On November 13, 1979, the licensee submitted a request to the NRC staff for authorization to decontaminate the reactor building atmosphere by controlled purging (feed and bleed) through the reactor building hydrogen control subsystem (Ref. 1). In a letter to the licensee on December 18, 1979, the staff withheld approval of the request to purge the building and stated that the NRC would prepare an Environmental Assessment on the subject in early 1980 (Ref. 4). The staff reviewed the licensee's submittal, including the discussion of various alternatives to reactor building purging. As a result of that review, the staff requested additional information in the form of 33 questions on December 18, 1979 (Ref. 5). The licensee responded to the staff's request on January 4, 1980 (Ref. 6). Pursuant to the requirements set forth in the Commission policy statement of November 21, 1979 (Ref. 7) and the February 11, 1980 Order by the Director of the Office of Nuclear Reactor Regulation (Ref. 8), the NRC staff prepared a draft Environmental Assessment (NUREG-0662) in March 1980 (Ref. 2). That assessment included the staff's evaluation of licensee modifications to the reactor building hydrogen control subsystem, as well as a discussion of the need to decontaminate the reactor building atmosphere and alternatives to controlled purging to the environment. The original comment period for NUREG-0662 was scheduled to end April 17, 1980, but was extended by the Commission, at the request of the Governor of Pennsylvania, to May 16, 1980. This Final Environmental Assessment (NUREG-0662) is based on information and public comments received since publication of the draft Assessment and includes an update of the NRC staff's evaluation of reactor building decontamination alternatives, and an evaluation of potential physical and psychological health effects associated with reactor building purging.

4.0 Reactor Building Airborne Activity

4.1 Gas Sampling and Analysis

Three types of reactor building air samples are periodically collected to determine the nature of airborne contaminants in the building. Samples are taken for noble gases (including Kr-85), particulate matter, and radioiodine activity. Air samples are taken from two points in the reactor building. The samples are transmitted through two lines running from the dome to the reactor-building air-sample gaseous monitor.

Redundant inlet and discharge valves are provided for the system to prevent a single-active failure of any valve from impairing the function of the system. Samples are analyzed with a gas chromatograph to determine hydrogen content and isotopic composition is determined with a gamma spectrum analyzer. The Kr-85 gas activity in the reactor building atmosphere is determined by gamma spectroscopy techniques. Isotopic identification is made on the basis of the discrete energy levels at which gamma rays are absorbed in a germanium-lithium (GeLi) detector. Particulate activity is determined in the reactor building atmosphere by pumping building air through a filter. Particulate activity is removed from the air by filters, which are then analyzed using gamma spectroscopy. To determine the concentrations of the different types of iodine in the atmosphere, a sample of the reactor building air is pumped through a series of filters. Separation of the different forms of iodine is accomplished based on the relative affinity of each iodine species for a specific filter medium. Each filter is then analyzed using gamma spectroscopy.

In addition to the routine sampling for noble gases, particulates, and iodine, samples are obtained for tritium, and gross beta analyses. The results of the sampling program are presented in the following section, "Source Term Derivation."

4.2 Source Term Derivation

Sample results to date indicate that the dominant isotope within the reactor building atmosphere is Kr-85. Radioactive decay has reduced other radioactive isotopes of xenon and krypton to negligible quantities. Reactor building gas sample data from May to December 1979 indicate the source term for Kr-85 is 0.78 μCi/cc, with a standard deviation of ±0.23 μCi/cc. Since late 1979, reactor building gas-sampling techniques were improved to eliminate small sample line leaks and to allow for direct counting of the samples. With these improved sampling techniques, the source term for Kr-85 is measured to be 1.04 μCi/cc, with a smaller standard deviation of ± 0.03 μCi/cc. This smaller standard deviation indicates improved sampling accuracy. Other noble gases (e.g., Xe-131m, Xe-133m, Xe-133, Xe-135) have decayed to below minimum detectable activity (MDA) levels of 1×10^{-6} μCi/cc.

Radioactive decay has reduced iodine levels in the reactor building to below MDA levels of 1×10^{-9} μCi/cc. Particulate levels, primarily those of cesium-137, are less than 1×10^{-9} μCi/cc. Reactor building air samples have been specifically analyzed for strontium-89/90. Those analyses, plus the results of gross beta analyses, show that airborne strontium-89/90 levels are small, that is, in the order of 1×10^{-10} μCi/cc. The airborne concentration levels of all the above isotopes are measured to be below the maximum permissible concentration (MPC) levels listed in Table 1 of Appendix B to 10 CFR 20 (Ref. 9). Additionally, it should be noted that all of the decontamination alternatives (listed in Section 6) include systems (e.g., HEPA, and charcoal filters) which, if utilized, would further reduce the already small airborne concentration of these isotopes. The removal efficiency (99.97% or better) of these filters would reduce any release of particulate radiation to negligible quantities.

Airborne tritium concentrations in the reactor building are measured to be approximately 8.4×10^{-5} µCi/cc. This value is consistent with the calculated estimates of airborne tritium concentration which is based on reactor building relative humidity and on tritium measured in the reactor building sump water. This concentration is 10 times lower than the maximum permissible airborne concentration limit for tritium listed in Table 1 of Appendix B to 10 CFR 20 (Ref. 9).

5.0 Need for Decontamination of the Reactor Building Atmosphere

5.1 Summary

The reactor building atmosphere needs to be decontaminated in a timely manner primarily to permit the less restricted access to the reactor building necessary to gather information, to maintain equipment, and to proceed toward total decontamination of the Unit 2 facility. At present, the Kr-85 dispersed inside the reactor building atmosphere limits operations which could be conducted inside the building to preliminary contamination data gathering. Following decontamination of the reactor building atmosphere, larger scale activities, such as detailed radiation mapping, preliminary decontamination, and shielding placement, will be possible since lowered radiation exposure levels will reduce the need for personnel protective gear.

The eventual removal of fuel from the reactor vessel (or defueling) is an important milestone in the overall cleanup effort which cannot proceed until atmospheric decontamination is completed. Defueling will eliminate the small, but finite, potential for inadvertent core recriticality, which could occur, for example, from accidental boron dilution of the reactor coolant. In addition, defueling will eliminate the major source of radioactive material in the reactor building. Decontamination of Kr-85 in the atmosphere would also provide the less restricted access to the reactor building needed to repair or replace core nuclear instrumentation, to maintain the reactor building air cooling system, and to support processing of the reactor building sump water.

Although difficult to quantify, present conditions inside the reactor building pose risks to the physical and psychological health of residents in the Harrisburg-Middletown area. Public health risks, including psychological stress, will continue to be a concern throughout the cleanup process. In the NRC staff's opinion, elimination of these risks require a safe and expeditious completion of all cleanup activities at the site. Decontamination of the reactor building atmosphere is the next required step in achieving this goal.

5.2 Discussion

The TMI-2 reactor is presently being maintained safely shut down, with damaged fuel in the reactor vessel. The extent of fuel damage and the present core configuration are unknown. It is important that the reactor continue to be maintained subcritical and that the damaged fuel inside the reactor be removed from the reactor vessel and placed in a safe configuration to eliminate any potential for core recriticality.

As the minimum negative impact, core recriticality would result in the production of additional radioactive material which would require decontamination. Core recriticality could also lead to further degradation of the reactor coolant system and the possibility of uncontrolled release of radioactivity to the environment.

The licensee is presently relying on boron injected into the reactor coolant system to maintain the core subcritical. Normally, this function is accomplished by inserting control rods into the core. During the accident, however, it is believed that some of the control rod material melted and may have drained out of the core. At present, most instrumentation provided for monitoring reactor neutron flux, and therefore providing feedback on boron effectiveness, is inoperable. Only one nuclear instrument channel is operating. If this instrument fails, direct measurement of neutron flux in the reactor core would not be possible. It would then be necessary to infer the status of the core by periodic sampling and analysis of boron concentration in the reactor coolant. Although the staff considers the potential for core recriticality to be of low probability, it will be a number of years before defueling is anticipated. In the interests of public and worker health and safety, the staff believes that removing the fuel in a timely fashion will eliminate the potential risk, no matter how small, associated with the core in its present condition. Since decontamination of the reactor building atmosphere is the necessary next step in the path leading to core defueling, it should be undertaken in a safe and expeditious manner. Purging the reactor building can achieve both of those goals.

While activities leading to core defueling are being undertaken, it will be necessary to continue direct core monitoring. To allow the remaining core monitoring instrumentation to deteriorate would pose additional risks to the public and to workers because of the potential for core recriticality to result in the generation of more radioactive fission products at Three Mile Island. Should this existing instrumentation fail it will be necessary to decontaminate the reactor building atmosphere to achieve the access necessary to repair or replace them.

At present, radiation levels in the reactor building at the 305- and 347-foot elevations would result in total body dose rates of approximately 2.3 rem/hour and 1.3 rem/hour, respectively. If a reactor building entry is made prior to decontamination of the atmosphere, heavy protective clothing and equipment will be required. The necessary gear, including self-contained respiratory equipment, radiation detectors, communications equipment, personnel dosimeters, and protective clothing would weigh approximately 85 pounds and would hamper the movement necessary for workers to perform decontamination or maintenance-related tasks inside the building. Heavy protective clothing would be expected to shield workers from essentially all of the direct beta radiation from the krypton cloud (150 rem/hour to unshielded skin), although some diffusion of the krypton through the suit would probably occur. This clothing, however, would not protect workers from gamma radiation or from high-energy beta-emitting radionuclides which are believed to contaminate surfaces inside the building.

Decontamination of the reactor building atmosphere would reduce the total body dose rate by 30% on the 305-foot elevation and by 75% on the 347-foot elevation (the operating floor) to 1.6 rem/hour and 0.3 rem/hour, respectively. The dose-rate values shown below provide an example of expected dose rates accruing to an individual in self-contained breathing apparatus and protective clothing.

Radiation Elevation 305 Feet	Dose Rate (Rem/Hour) Before Decontamination	After Decontamination
Gamma (total body)	2.3	1.6
Beta (skin)	0.8	0.8

Radiation Elevation 347 Feet	Before Decontamination	After Decontamination
Gamma (total body)	1.3	0.3
Beta (skin)	1.2	1.2

It should be noted that Kr-85 beta skin dose (approximately 150 rem/hour) is not a factor in this example due to the presence of protective clothing before decontamination and elimination of Kr-85 beta radiation after decontamination. Decontamination of the reactor building atmosphere, then, is necessary to reduce worker risk from gamma total-body exposures from Kr-85 and to eliminate and the risk and inefficiency of working in burdensome protective clothing (including risks involving tearing the protective suit and worker injuries due to falling).

The reactor building atmosphere, which is at 100% relative humidity, is currently being maintained at approximately 75°F by the reactor building air-cooling system. This cooling action is maintaining the reactor building at a slight negative pressure (approximately -0.7 psig) with respect to the outside atmosphere. This pressure differential prevents leakage of the reactor building atmosphere to the environment. Other factors that affect the pressure differential between the reactor building atmosphere and the outside atmosphere include: (1) pressure differentials caused by wind currents over and around the building, (2) changes in barometric pressure, (3) changes in external air temperatures, and (4) the solar heat load on the building. The building air- cooling fans (four operating, one standby) were qualified for three to four hours of continuous operation in a 100% relative humidity environment. Four fans have been operating nearly continuously since the March 28, 1979 accident in a high-humidity environment. It is not known if the standby fan is operable. The operating fans can reasonably be expected to fail sequentially over a period of time. Their sequential failure would result in a decrease of heat removal capability from the reactor building atmosphere and could ultimately cause the atmospheric pressure in the reactor building to increase and become positive relative to the outside atmosphere. The NRC staff has calculated that for worst-case conditions (i.e., all fans fail), this pressure could rise to as high as four psig. The reactor building has a design leakage rate of 0.2% by weight per day at 60 psig. The measured leakage rate of the reactor building during its most recent leak-rate test (conducted in early January 1978) was 0.095% by weight per day at 56 psig. Based on the relationship between observed leak rate and differential pressure, the staff calculates that uncontrolled leakage of Kr-85 from the reactor building would not exceed five curies per day. The corresponding beta skin dose to the person receiving maximum exposure from this leakage would be dependent on local meteorology (i.e., the dispersion factor or X/Q) which typically varies from 1×10^{-4} to 1×10^{-7} sec/m^3 Thus, the one-day dose could vary from approximately 0.02 millirems to 0.00002 millirems. In view of the fact that the annual average X/Q is approximately 6.7×10^{-6} sec/m^3 and uncontrolled leakage from the reactor building would involve small amounts of Kr-85, the staff does not consider such leakage likely to threaten the health and safety of the public. However, based on past public response to relatively small leaks of gaseous effluents to the environment, (e.g., leakage from the makeup and purification system resulting in a gaseous discharge of 0.3 Ci of Kr-85 on February 11, 1980), the staff believes that future uncontrolled leaks could generate significant psychological stress in the community. In the staff's view, a controlled purge, which is publicly announced, fully monitored, and conducted during favorable meteorological conditions, is preferable to uncontrolled leakage.

The reactor building cooling system will also perform a vital function following decontamination of the reactor building atmosphere. This system will be needed to maintain a reasonable working environment inside the building and allow expeditious building decontamination and defueling activities. Decontamination of the reactor building atmosphere would allow for cooling system maintenance and avoid recovery effort delays that might accompany cooling system failures.

Although a discussion of systems and alternatives for processing the reactor building sump water is not appropriate for this document (the forthcoming Programmatic Environmental Impact Statement is the appropriate document), access to the reactor building will be necessary to effectively support processing this water. Should NRC approve a system for processing the sump water, the licensee will require less restricted access to the reactor building to support processing with area washdowns. Area washdowns will assist in the removal of the crud and filterable material that would otherwise adhere to the walls and surfaces in the basement of the building as water levels decline. The primary reason for these washdowns is to protect workers from direct or airborne (from drying out) sources of radiation from the walls. Area washdowns will not be possible unless the reactor building atmosphere is decontaminated.

Lastly, the NRC staff believes expeditious decontaminaton of the reactor building atmosphere is necessary to reduce long-term psychological stress in the TMI area by shortening the time necessary to complete the entire cleanup project.

6.0 Decontamination Alternatives

6.1 No Action

The NRC staff has considered the possibiilty that no action be taken to decontaminate the TMI-2 reactor building atmosphere. This alternative would necessitate retaining the radioactive gas within the reactor building. This option has been rejected, however, as totally inappropriate for several reasons.

First, taking no action would subject the public to potential health and safety risks which exceed those of any other alternative, considered within this Environmental Assessment, for decontaminating the reactor building atmosphere. The potential risks associated with taking no action are discussed in detail in Section 5.0. These risks include possible core recriticality and corresponding production of additional radioactive materials. The NRC staff believes that minimizing these risks depends on access of workers to the reactor building to permit continuation of activities leading to eventual defueling. This access, in turn, depends on the decontamination of the reactor building atmosphere.

An indepth discussion of both public health and occupational risks resulting from the employment of other decontamination alternatives is presented in the following subsections. Public health risks for all alternatives have been determined to be negligible.

6.2 Reactor Building Purge Systems

6.2.1 Introduction

A number of purge methods could be used to decontaminate the reactor building atmosphere. The staff has evaluated four purge methods which could be implemented utilizing existing plant systems and structures and two other purge methods which would require either new or modified plant systems and structures. Those methods include: (1) a slow purge using the existing hydrogen control subsystem with releases from the unmodified 160-foot plant vent stack; (2) a fast purge using the existing hydrogen control subsystem and reactor building purge system with releases from the 160-foot plant vent stack; (3) an elevated purge using the existing hydrogen control subsystem and reactor building purge system with releases from the plant vent stack elevated to 400 feet; and (4) an elevated purge using the existing reactor building purge system with releases from a new 1000-foot stack.

In addition, the staff has evaluated two methods of purging proposed by the Union of Concerned Scientists in a report submitted to the Governor of Pennsylvania (Ref. 3). The two methods proposed are release of a heated plume from a 250-foot refractory lined stack and an elevated release at 1000 to 2000 feet through a relatively light-weight tube held aloft by a tethered balloon.

6.2.2 Slow Purge

The hydrogen control subsystem was originally installed for use as a backup system to the hydrogen recombiners. The system is being modified to allow variable flow rates up to a maximum of 1000 cfm. Actual purge rates during a purge would be dependent on meteorological conditions and reactor building concentrations of Kr-85. The hydrogen control subsystem would withdraw the reactor building atmosphere through a filter system, monitor the effluent radioactivity levels, and discharge the effluent through the 160-foot plant vent stack to the environment.

These releases would be made based on existing meteorological conditions such that release rates of radioactive materials would be controlled to ensure that the requirements of 10 CFR Part 20, the design objectives of 10 CFR Part 50, Appendix I (Ref. 11) and the applicable requirements of 40 CFR Part 190.10 (Ref. 12) are not exceeded.

6.2.2.1 System Description and Operation

The proposed purge of the Unit 2 reactor building atmosphere to the environment would use the hydrogen control subsystem of the reactor building ventilation system. Radioactive gases purged from the reactor building would be diluted with the exhaust air from the auxiliary and fuel building ventilation systems and released through the Unit 2 vent stack, which is 160 feet above grade level. The major components of this system include: an exhaust fan, isolation valves, filtration system, and a radiation monitoring system. The filtration system consists of a prefilter, a HEPA filter, an activated charcoal filter, and a downstream HEPA filter. Replacement air to the reactor building would be supplied through the reactor building pressurization valve.

The slow rate purge alternative recommended by the NRC staff would be carried out within several limiting conditions. Most importantly, purging would be controlled to limit the cumulative maximum individual offsite dose resulting from the purge to less than the annual dose design objectives (5 mrem total body, 15 mrem skin) of Appendix I to 10 CFR Part 50 (Ref. 11). Doses would be tracked during actual purging by using real-time meteorological data to calculate hourly dose rates in affected sectors surrounding the plant. (The region around TMI is divided into 16 directional sectors; wind directional changes during purging will result in differing dose rates for individual sectors.)

Cumulative dose, based on these calculated dose rates in each affected sector, would be updated hourly throughout the purge process. No hypothetical person in any sector would be permitted to receive a dose in excess of the Appendix I dose design objective. For example, if the calculated cumulative dose to a hypothetical person, based on actual Kr-85 release rates and real-time meteorology, reached the annual Appendix I total body (5 mrem) or beta skin (15 mrem) dose objective in the North sector, purging would be discontinued when existing wind conditions could result in any incremental increase in dose to the North sector.

In addition to Appendix I constraints, the slow purge procedure would be limited by the existing Three Mile Island effluent release technical specifications for noble gases (Ref. 13). These specifications consist of an instantaneous release rate limit and a quarterly average release rate limit. Although these specifications have dose limitations as their bases, they have been implemented as noble gas release rate limits. Release rate alone determines conformance or non-conformance with the technical specifications. As applied to the slow purge rate alternative, the technical specifications effectively apply only to Kr-85 since it is the remaining noble gas in the reactor building.

One Kr-85 release rate technical specification requires that the instantaneous rate not exceed 45,000 μCi/sec. This instantaneous limit is derived from the annual average X/Q* (6.7×10^{-6} sec/m^3) for the TMI site and the maximum permissible concentration (MPC) for Kr-85 in unrestricted areas (3×10^{-7} μCi/cc) as listed in 10 CFR 20, Appendix B, Table 2, Column 1 (Ref. 9). This specification provides for short-term operational flexibility. Any extended release at this relatively high rate would quickly become limiting to operation because the cumulative Appendix I dose restriction also limits the conduct of the purge alternative (Ref. 11).

A quarterly averaged release rate technical specification limit of 7200 μCi/sec, based on a more restrictive X/Q value (4.2×10^{-5} sec/m^3), would also be applicable to a slow purge. This quarterly averaged release rate limit is based on not exceeding, in one quarter, four times the annual Appendix I dose design objective. Again this

*See the Glossary for a definition of X/Q.

specification provides for relatively short periods of operational flexibility because relatively high release rates (and hence dose rates) can be averaged in a quarter with relatively low release rates. Cumulative Appendix I dose, however, cannot be exceeded.

The dose rate during a purge period is dependent on the product of three variables; the Kr-85 release rate, meteorological dispersion factor (X/Q) and the Kr-85 dose conversion factor. Only the Kr-85 dose conversion factor is a fixed value, $\frac{\text{mrem-m}^3}{\text{Ci-sec}}$. While meteorology (X/Q, sec/m^3) cannot be controlled during a purge, release rate (Ci/sec) can be adjusted to limit the resulting dose rate. During periods of less favorable meteorology, therefore, release rates can be selectively reduced to maintain desired dose rate levels. Detailed licensee procedures for maintaining acceptable purge dose rates during varying meteological conditions by adjusting release rates, have been reviewed and approved by the NRC staff. In addition, members of the NRC onsite staff will monitor the licensee's actions during the entire purge.

At the onset of the slow purge scenario, purge rates would be expected to be in the range of 50 to 75 cfm. As the Kr-85 concentration in the reactor building decreases, the purge rate would be increased to a maximum of approximately 1000 cfm. The purge rate during any period would be dependent on the aforementioned limiting conditions.

The incremental dose (mrem) for each purge period is obtained from the product of the dose rate (mrem/sec) and time duration (sec) of the period. The total dose due to the entire purge of 57,000 Ci of Kr-85 is obtained by summing the individual incremental doses from each purge period. The staff estimates that over a 60-day period it would require approximately 30 days of actual purging to reach the MPC level of 1×10^{-5} μCi/cc in the reactor building.

During purge operations with the hydrogen control subsystem, makeup air would be supplied to the reactor building through the reactor building pressurization valve. This ensures that air would flow into the reactor building and a small negative pressure relative to the auxiliary building would be maintained with the hydrogen control subsystem exhaust fan. The reactor building pressurization valve is interlocked with the exhaust fan to shut when the fan stops. Nevertheless, there is the potential for backflow of contaminated reactor building air through the reactor building pressurization valve to the 328-foot level of the auxiliary building if the reactor building pressure is not maintained slightly negative with respect to the auxiliary building. General area radiation monitors in the auxiliary building would detect the radioactivity to signal for isolation of the reactor building by stopping the purge.

Flow rate, temperature, and radiation level of hydrogen control subsystem flow would be monitored during purging operations. System flow rate, temperature, and radiation level are measured at the hydrogen control subsystem fan discharge point. General area radiation levels around the filter housing on the 328-foot level of the auxiliary building would be monitored by a local radiation monitor. General area radiation monitors have local and remote readouts in the Unit 2 control room.

Table 6.2-1 provides a list of the major components used in the hydrogen control subsystem. The subsystem exhaust fan is interlocked to stop automatically and valves close automatically to isolate the system if high activity is detected in the effluent.

Figure 6.2-1 provides a flow diagram of the hydrogen control subsystem. Modifications to the hydrogen control subsystem would include (1) replacing the hydrogen control subsystem exhaust fan with a fan capable of producing a maximum flow of 1000 cfm, (2) recommissioning the auxiliary building and fuel-handling building filter trains, (3) calibrating and reactivating the stack monitor, (4) securing the supplementary filter train by turning off the supplementary fans and closing the isolation door from the stack inlet plenum to the filters, and (5) uncapping the plant vent stack.

Table 6.2-1 Hydrogen Control Subsystem

System	Operator	Effects of Loss of Operator	Auto-Action	Interlocks
Fan AH-E-34	Electrical	Reduced flow thru system	Stop fan	High activity on HPR-229*
Pressure Sensing Line Isolation Valves A-V5 & AH-V6	Electrical	Fail as is	None	None
RB Pressurization Valve AH-V7	Air operated	Valve fail closed	Closes on loss of power	When fan AH-E-34 stops, valve shuts
RB Hydrogen Control Valve AH-V25	Electrical motor-operated local control	Fail as is	None	None
RB Hydrogen Control Discharge Valve AH-V36	Air operated	Fail closed	Opens when fan starts	None
Reactor Bldg. Hydrogen Control Isolation Valve AH-V52	Air operated	Fail closed	None	None
AH-V-3A, B RB Isolation Valves	Air operated	Fail closed on high radiation,	Fail closed loss of power	None

*Monitor mounted in the exhaust duct downstream of the exhaust fan.

6.2.2.2 Occupational Exposure

The design criteria for the existing hydrogen control subsystem is consistent with the "as low as reasonably achievable" guidance of 10 CFR Part 20 and Regulatory Guide 8.8 (Ref. 14). Control during a purging interval would be exercised remotely from the Unit 2 control room. However, an auxiliary operator would be required to be in the auxiliary building during system operation. This operator would have communication ties with the control room and be stationed in a low-radiation area.

The dose to operators during processing will be approximately 0.8 person-rem. Changing the two HEPA filters will also contribute to occupational exposure. These filters have a surface dose rate of approximately 0.17 R/hr and filter changeout will require approximately one-half hour per filter. It is expected that the filters will be changed only once at the end of the purge operation, resulting in approximately 0.4 person-rem. Therefore, the total exposure for processing and filter changeout would be approximately 1.2 person-rem.

6.2.2.3 Environmental Impact

Slow Purge - Using the Hydrogen Control Subsystem With Release from the Unmodified 160-foot Plant Vent Stack.

Based on the release of 57,000 ci, and the annual average dispersion factor of 6.7×10^{-6} sec/m^3, the beta skin dose is estimated to be 11 mrem and the gamma total body dose is estimated to be 0.2 mrem. These numbers represent the maximum dose that could occur to an individual present at the site boundary for 70% of the release period.

In the staff's evaluation, an annual average X/Q is used to calculate offsite concentration and dose. The annual average X/Q is used because predictions of actual meteorological conditions for a particular time are impossible. However, the probabilities are high for having hourly atmospheric diffusion conditions during any season that would provide a considerably less conservative X/Q than the annual average X/Q used by the staff in their evaluation.

The dose received by the population residing in the 50-mile radius around the reactor due to the release of the 57,000 Ci of Kr-85 was evaluated. The methods used for this calculation are described in Regulatory Guide 1.109 (Ref. 15). A standard grid was employed which segmented the population into 160 elements. This grid contains 16 sectors (N clockwise through NNW) each centered on the appropriate direction. Each sector is divided into segments at standard distances of 2000 ft (.37 mi), 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles. The meteorological dispersion parameters which were used were the same as those that were used for the Final Supplement to the Final Environmental Statement for Three Mile Island Nuclear Station, Unit 2, (NUREG-0112), issued December 1976 (Ref. 16).

The meteorological dispersion parameters represent annual average conditions and were developed on the basis of historical data collected at the site. The 1980 population was taken from NUREG-0558 (Population Dose and Health Impact of the Accident at the Three Mile Island Nuclear Station) (Ref. 17).

The 50-mile population dose calculated by this method is 0.76 person-rem total body due to the gamma component of krypton decay and 63 person-rem skin due to the beta component of the krypton decay.

6.2.2.4 Accident Analysis

The components for the purge system are located in the Unit 2 auxiliary building. A major rupture in the purge system would allow Kr-85 to be released to the auxiliary building. Any Kr-85 released to this building would be exhausted through the auxiliary building ventilation system to the plant stack. This path would be the same release pathway as that for the normal purge system.

The worst-case accident would be an inadvertent initiation of the purge system at maximum flow of 1000 cfm with a Kr-85 concentration in the reactor building atmosphere of 1 uCi/cc. In our analysis we assumed that 30 minutes were required for the operator to detect the leak and isolate the system. The 30 minutes used in this analysis is extremely conservative and was used only for calculational purposes. During actual operation a high radiation alarm moni'' would automatically stop the hydrogen control subsystem purge fan and valve closure would automatically olate the reactor bui'ding.

In a 30-minute period, a total of 850 curies would be released. For conservatism, the meteorological dispersion parameter (X/Q) used for this accident scenario was 6.8×10^{-4} sec/m^3 which is 100 times higher than t'~ annual average value. Using Regulatory Guide 1.109 (Ref. 15), the staff calculates that the total body gamma sose to an individual at the site boundary would be 0.3 mrem and that the beta skin dose would be 25 mrem. The total body dose represents only a small fraction of the 10 CFR Part 100 limit (Ref. 18) of 25 rem. (Skin dose limits are not included in 10 CFR Part 100.)

6.2.3 Fast Purge

The reactor building purge system is an existing system originally installed for purging the reactor building atmosphere. Use of the reactor building purge system in conjunction with the hydrogen control subsystem represents a variation in the purging alternatives for decontaminating the Unit 2 reactor building atmosphere. A scenario for this purge is described in Subsection 6.2.3.1 This variation in the purging alternative would function only under meteorological conditions favorable for atmospheric dispersion. In addition, the purge could not be conducted in accordance with the existing instantaneous and quarterly average release rate limits of the existing radiological effluent technical specifications. The fast purge would be conducted in accordance with the weighted annual average requirements of 10 CFR Part 20 (Ref. 19), the design objectives of 10 CFR Part 50, Appendix I (Ref. 11), and the applicable requirements of 40 CFR Part 190.10 (Ref. 12). Additionally, the fast purge would be conducted to conservatively limit the maximum beta skin dose rate to 3 mrem/hr, since technical specification limits which normally accomplish this would have to be waived, as discussed above.

The reactor building purge system is capable of purging the building at flow rates of 5,000-50,000 cfm. Actual purge rates authorized during any time interval would be dependent on meteorological conditions and reactor building concentrations. Like the hydrogen control subsystem, this system would remove the reactor building atmosphere through a filter system and discharge it through the 160-foot plant vent stack to the environment. The advantage of using the reactor building purge system in conjunction with the hydrogen control subsystem is that, given the required favorable meteorology, it could decontaminate the reactor building atmosphere in five days of actual purging over a total elapsed time as short as approximately 14 days. Accordingly, the calendar time frame associated with heightened psychological stress during the conduct of the purge would be minimized.

6.2.3.1 System Description and Operation

The fast purge alternative would use the hydrogen control subsystem described in Section 6.2.1 in conjunction with the reactor building purge system. The reactor building purge system consists of two air-moving units, each of which has a flow rate that can be varied from 5,000 to 25,000 cfm. These units can be operated separately or simultaneously. During operation of the system, radioactive gases purged from the reactor building would be diluted with exhaust air from the auxiliary and fuel handling building ventilation systems and released via the unit 2 plant vent stack, which is 160 feet above grade level. This purge system is operated from the Unit 2 control room. However, because of modifications to the system to allow for flow control, an auxiliary operator would be stationed in the auxiliary building to control the purge flow rate. The auxiliary operator would have communication ties with the control room and would be stationed in a low-radiation area.

Figure 6.2-2 provides a flow diagram of the reactor building purge system. The major components of this system include two air supply fans and filter units, two isolation valves in each purge air supply duct, two air exhaust fans and filter units, and two isolation valves in each purge air exhaust duct. The exhaust filter units consist of a prefilter, a HEPA filter bank and a second HEPA filter bank.

The slow purge method evaluated in Section 6.2.2 was based upon not exceeding the existing Appendix B Technical Specification limit (45,000 μCi/sec) for Krypton-85 (Kr-85) releases through the 160 foot plant vent stack (Ref. 9). These Technical Specification limits are based on conservative annual average meteorological conditions, where X/ = 6.7 x 10^{-6} sec/m^3. However, by controlling the purge rates to take advantage of more favorable meteorological conditions, higher purge rates can be achieved while still not exceeding the requirements of 10 CFR Part 20 (Ref. 19), the design objectives of 10 CFR Part 50, Appendix I (Ref. 11) and the applicable requirements of 40 CFR Part 190.10 (Ref. 12).

When favorable meteorological conditions exist, the hydrogen control subsystem would be operated at its maximum flow rate of 1000 cfm until the Kr-85 concentration in the reactor building is reduced to 0.22 uCi/cc. It would require approximately 50 hours to reduce the current reactor building Kr-85 concentration of 1.0 uCi/cc to 0.22 uCi/cc. When the reactor building Kr-85 concentration is reduced to 0.22 uCi/cc, the hydrogen control subsystem would be secured and the the reactor building purge system started with an approximate flow rate of 5000 cfm. The reactor building purge system would operate at 5000 cfm for approximately 70 hours to reduce the building concentration of Kr-85 to MPC (1 x 10^{-5} uCi/cc). Thus, the total actual purge time using both systems would be approximately 120 hours. The calendar time frame necessary to complete the fast purge scenario is dependent upon achieving favorable meteorology and is especially sensitive to the seasonal variations that can occur (see discussion in Section 6.2.3.3).

6.2.3.2 Occupational Exposure

The occupational exposure anticipated from the fast purge scenario is approximately the same as for the slow purge scenario as discussed in Section 6.2.2.2.

6.2.3.3 Environmental Impact

The fast purge environmental impact would be approximately the same as for the slow purge as discussed in Section 6.2.2.3.

For the fast purge during the spring season (March-May) there is a fair likelihood of being able to expeditiously release and maintain sufficiently low doses to the public in accordance with the criteria discussed in Section 6.2.3.1. We estimate that favorable meteorology during these months may permit the fast purge option to be accomplished within a 2-calendar week period. However, for the fast purge during the summer and fall months (June-October), we estimate, based on historical data which show a small probability of favorable meteorological conditions, that this alternative would require approximately two calendar months to complete. Thus, given the June thru October meteorological conditions, the calendar time frame necessary for both the fast purge and slow purge are essentially equivalent. As the period of favorable meteorology (i.e., March-May) is nearly over, the staff considers the fast purge to be a less desirable alternative for the following reasons:

(1) The advantage of the fast purge, namely a lessening of potential psychological stress for area residents, would be lost during the summer months when total elapsed time required for both fast and slow purge alternatives are essentially the same.

(2) Reactor building purging should not be delayed past the summer and fall months to allow for better winter meteorological conditions for those reasons elaborated in Section 5.0.

6.2.3.4 Accident Analysis

The accident analysis described in Section 6.2.2.4 would apply to this alternative.

6.2.4 Elevated Release Points

6.2.4.1 Introduction

Stacks are normally designed to assure that effluent exit velocities will give maximum rise to releases and eliminate the wake-cavity effects of adjacent structures. Factors affecting meteorological dispersion of stack effluents include the height and position of nearby structures and the layout of local terrain. The existing plant vent stack is 160 feet above grade, with an exit diameter of 9 feet. In order to evaluate the dose reduction offered by increasing stack height, the staff has evaluated the alternatives of raising the existing stack to 400 feet or construction of a new 1000-foot stack.

6.2.4.2 Extending Stack Height to 400 Feet

6.2.4.2.1 Description

A temporary sheet metal extension with the same diameter as the existing stack, could be used to elevate the existing plant stack to 400 feet above grade. The extension would be surrounded with scaffolding, which would be used to support the extension with the aid of guy wires. The existing stack could also be elevated to 400 feet by the addition of 10-foot sections of the carbon-steel pipes. These sections would have the same diameter as the existing stack.

Assuming that procurement of the necessary materials for extending the stack can be readily accomplished, the staff estimates that the engineering design, procurement, construction, and leak testing of either variation would require a minimum of four to five months. This estimate does not consider the potential interferences of existing and new structures (e.g., processed water storage tanks) which may result in further schedule delays.

6.2.4.2.2 Occupational Exposure

Occupational exposures described in Section 6.2.2.2 would apply to this alternative.

6.2.4.2.3 Environmental Impact

An increase in stack height to 400 ft would eliminate the effect of the reactor building wake cavity however, the stack would remain within the wake cavity of the site cooling towers. In addition, the plant location in a river valley surrounded by higher elevation terrain diminish the effects of an elevated release point of 400 feet. An increase in the plant stack height (up to 400 ft) would reduce the already negligible (see Section 7.1) dose to the maximum exposed individual by a factor of approximately eight below the doses estimated for the fast or slow purge.

6.2.4.2.4 Accident Analysis

The accident analysis described in Section 6.2.2.4 would apply to this alternative.

6.2.4.3 Constructing a 1000-Foot Stack

The staff has evaluated the dose reduction benefit resulting from the construction of a 1000-foot stack.

A 1000-foot stack would assure that releases are unhindered from the effects of all onsite structures. The technology for constructing a stack this height is well established.

A stack 1000 feet high would require, at a minimum, a 60-foot diameter base. Construction of a foundation this size would require not less than three months and construction of the remainder of the stack would require approximately six months. Additional design, engineering, construction, and testing time required to connect the stack with the existing purge system and ensure proper operation would add two to three months to the installation schedule. Therefore, the staff estimates that a minimum of 11 months would be required to construct and make functional a new 1000-foot stack.

6.2.4.3.1 Occupational Exposure

Occupational exposures described in Section 6.2.2.2 would apply to this alternative.

6.2.4.3.2 Environmental Impact

A stack release at 1000 feet would physically place radioactive effluents above the effects of the cooling tower wake cavity and nearby terrain and would result in reducing offsite doses to the maximally exposed individual by a factor of approximately 230 below the doses estimated for the fast or slow purge.

6.2.4.3.3 Accident Analysis

The accident analysis described in Section 6.2.2.4 would apply to this alternative.

6.2.5 Staff Evaluation of Union of Concerned Scientist Elevated Release Proposals

6.2.5.1 Introduction

In response to a request by the Governor of Pennsylvania, the Union of Concerned Scientists (UCS) evaluated the health and safety consequences of the disposition of the reactor building atmosphere including the purging alternative recommended by the NRC staff in its draft Environmental Assessment (NUREG-0662). In their report to the Governor (Ref. 3), the UCS reported that based on "current evidence of effects of whole body radiation on human populations, ... no health effects would be anticipated as a result of the 'ground release' venting." However, the UCS did not recommend purging, as proposed by the staff, because of the potential psychological stress UCS believes purging might induce. As a result, the UCS proposed two alternative means of purging the reactor building which they believe will minimize potential psychological stress. The first method proposes purging by heating the effluent with an incinerator prior to releasing it through a 250-foot refractory lined stack. The second method proposes an elevated release at 1000-2000 feet through a relatively light-weight tube held aloft by a tethered ballon.

6.2.5.2 Hot Plume Release Through a 250-Foot Stack

6.2.5.2.1 Description

The staff has evaluated the Union of Concerned Scientists (USC) proposal to construct an incinerator (and stack) to heat the effluent purged from the reactor building. Under ideal conditions, an incinerator of this type should be located as close as possible to the auxiliary building to minimize the engineering and construction effort necessary to interface with the reactor building purge system. UCS "rough estimates" place the construction time for an incinerator facility at from seven to nine months. This time estimate does not include time requirements for design, engineering, procurement of material, and pre-operational testing. The staff estimates for these required efforts would add at least two months to the overall construction effort, resulting in a minimum schedule of nine months for system availability.

6.2.5.2.2 Occupational Exposure

Occupational exposures described in Section 6.2.2.2 would apply to this alternative.

6.2.5.2.3 Environmental Impact

Staff evaluations show that dose reductions can be achieved if heat is added in sufficient quantities to allow the effluents to raise above the wake cavity of the cooling towers. The release of a heated plume from a 250-foot stack would result in reducing offsite doses to the maximally exposed individual by a factor of approximately 30 below the doses estimated for the fast or low purge.

6.2.5.2.4 Accident Analysis

The impact of an accident involving this alternative would result in a total-body dose which is approximately five times greater than the slow purge accident dose discussed in Section 6.2.2.4. These doses would still represent a small fraction of 10 CFR Part 100 accident-dose limits (Ref. 18).

6.2.5.3 The Tethered Balloon/Tube Release at 2000 Feet

6.2.5.3.1 Description

The staff has evaluated the UCS proposal to purge the reactor building atmosphere through a reinforced fabric tube held aloft at 2000 feet above Three Mile Island by a tethered balloon (Also see Section 9.2.5). As stated by the UCS, this technique is unique and untried and would require further study to determine its feasibility. In addition, the UCS stated that they did not know if suitable space was available on Three Mile Island to implement this alternative.

In general, the staff finds the UCS proposal, while not without problems, technically workable and probably capable of being implemented within a year from the time the decision is made to use it.

The major problem with the UCS proposal is that, at present, there is no existing area on Three Mile Island which is suitable for launching the tethered balloon and its attached 2000-foot fabric tube. The UCS has stated that their proposal would require unobstructed ground and air space approximately 2000 feet long by 200 feet wide. The staff has examined Three Mile Island for potential sites of sufficient size to implement the UCS proposal.

The island is approximately 11,000 feet in length by 1,700 feet in width. The northern one-third of the island is occupied by Three Mile Island Nuclear Station Units 1 and 2. The southern part of the island contains some open area, a fairly large wooded area, and a shallow basin area that is prone to flooding. The area with the most open space is south of the Unit 2 cooling towers and includes an existing parking lot. The staff estimates the open space to be approximately 200 feet or more wide and 1500 feet long. Some trees in the wooded area of the island would have to be removed to enlarge the area.

This potential site is a considerable distance from the auxiliary building and the reactor building purge system with which it would have to interface. The large distance would magnify the engineering and construction effort involved, and would ultimately impact the schedule for system availability. A detailed design and layout of the interconnecting piping between the auxiliary building and the launch site would have to be performed.

The piping would have to be buried (at least in some locations) in order not to restrict normal traffic (e.g., solid radwaste shipments, concrete truck deliveries, etc.) about the site. The piping would require leak testing following welding to ensure that no gas bypass pathways exist. The need for booster pumps would have to be determined in a detailed engineering evaluation. The staff has also consulted with the Department of Energy's (DOE) Ames Laboratory concerning the feasibility of the UCS balloon proposal. In their judgment, the first 500 to 1000 feet of elevation crucial in determining what effect wind shear and air turbulence will have on fabric tube behavior. Testing is recommended. The staff concurs with this observation. Thus, a test of the integrity of the reinforced fabric tube (1-foot diameter) under different wind shear and air turbulence conditions would be required. The staff envisions these tasks as a major design effort. The staff has determined that the schedule required to accomplish these actions and demonstrate system operability is longer than the timetable estimated to the UCS for system availability.

The UCS stated that a timetable for a tethered balloon system was "somewhat difficult to estimate" but projected a schedule of four to seven months. This schedule is based on the availability of a suitable location on Three Mile Island for system implementation and successful completion of feasibility tests. Based on the remote location of suitable land area from the auxiliary building, the staff believes that the UCS has underestimated the engineering and construction effort required to maje this technique workable. The staff estimates that this effort would require from 7 to 10 months to make the tethered balloon system operable. The staff does not believe that postponing decontamination of the reactor building atmosphere for this period of time is acceptable for the reasons discussed in Section 5.0.

6.2.5.3.2 Occupational Exposure

Provided adequate controls are established to isolate or bury the required interconnecting piping, the occupational exposures described in Section 6.2.2.2 would apply to this alternative.

6.2.5.3.3 Environmental Impact

An elevated release at 2000 feet would physically place radioactive effluents above the effects of the cooling tower wake cavity and nearby terrain and would result in reducing offsite doses to the maximum exposed individual by a factor of approximately 300 below the doses estimated for the fast or slow purge. However, the staff would have to assess the psychological impact of this highly visible alternative on nearby residents.

6.2.5.3.4 Accident Analysis

The accident analysis described in Section 6.2.5.2.4 would apply to this alternative.

6.2.6 Summary

The staff has evaluated six alternative methods for purging the contaminated reactor building atmosphere to the environment. Those methods include (1) a slow purge using the existing hydrogen control subsystem with releases from the unmodified 160-foot plant vent stack, (2) a fast purge using the existing hydrogen control subsystem and reactor building purge system with releases from the 160-foot plant vent stack, (3) an elevated purge using the existing hydrogen control subsystem and reactor building purge system with releases from the plant vent stack elevated to 400 feet, (4) an elevated purge using the reactor building purge system with releases from a new 1000-foot. stack, (5) a hot plume release using the reactor building purge system and a new incinerator and 250-foot stack (a UCS proposal), and (6) an elevated purge using the reactor building purge system and a reinforced fabric tube held aloft at 2000 feet by a tethered balloon (a UCS proposal).

All six purge alternatives are similar in some respects. All the proposed alternatives would result in approximately the same occupational exposure and the consequences of a postulated accidental release are also roughly equivalent. All the alternatives are capable of being implemented in accordance with the requirements of 10 CFR Part 20 (Ref. 19), the dose design objectives of 10 CFR Part 50, Appendix I, (Ref 15), and the applicable requirements of 40 CFR 190.10 (Ref. 12). No health effects would be anticipated from implementing any of the six purge alternatives (see Section 7.1).

However, there are significant differences among these alternatives. The slow purge and fast purge could essentially be implemented immediately (except for meteorological constraints for the fast purge). The remaining four alternatives would require modifications to plant systems and structures resulting in estimated schedules for system availability ranging from a minimum of four to five months (stack modified to 400 feet) to as long as 11 months (a new 1000-foot stack). Another potential difference associated with the various purge alternatives is the potential psychological impact that each might have. In fact, the UCS proposed their variations of the purge alternative not because of concern over health effects (none are anticipated), but as a means of reducing potential psychological stress. Because of inherent and uncertain delays, the NRC staff does not believe that the UCS proposals would succeed in alleviating psychological stress. On the contrary, the tethered balloon could even augment stress, depending on public perception. A tethered balloon would be easily visible to the nearby residents and would be an attraction of sorts that may create as much stress as it is intended to alleviate.

The NRC staff supports the slow purge alternative as the best means of decontaminating the reactor building atmosphere, thereby expediting the continued cleanup of the plant in a safe manner. In the staff's opinion, the best means of alleviating psychological stress in the vicinity around the plant is to complete the overall recovery effort safely and quickly.

6.3 Selective Absorption System

6.3.1 Introduction

The selective absorption system evaluated by the NRC staff would operate by withdrawing gases from the reactor building, separating essentially all the krypton from the gases, and returning the gases to the reactor building. Krypton is separated from other gases in a combination absorption stripping column which operates at greater than atmospheric pressure and uses a liquid fluorocarbon as a solvent. The separated and concentrated krypton may then be stored onsite or transported offsite for disposal. Alternatively, krypton gas in containers could be transported to and released at some remote site.

6.3.2 System Description and Operation

A fluorocarbon absorption process for removing noble gas fission products (krypton and xenon), carbon-14, and other radioactive contaminants from gaseous waste, has been under development since 1967 by Union Carbide at Oak Ridge National Laboratory (ORNL). Following their initial work to obtain solvent chemistry information and to develop the process system, ORNL personnel construc J a small pilot plant. This pilot plant utilizes a single absorption column process with a maximum gas flow rate of 15.0 scfm and has been in operation since 1978. Actual removal efficiencies greater than 99.9% for krypton have been obtained. However, these efficiencies were obtained for influent concentrations of noble gases substantially higher than those existing in the reactor building. Based on the results of the developmental and pilot plant test programs, ORNL personnel are optimistic that their absorption process could be used at Three Mile Island (TMI).

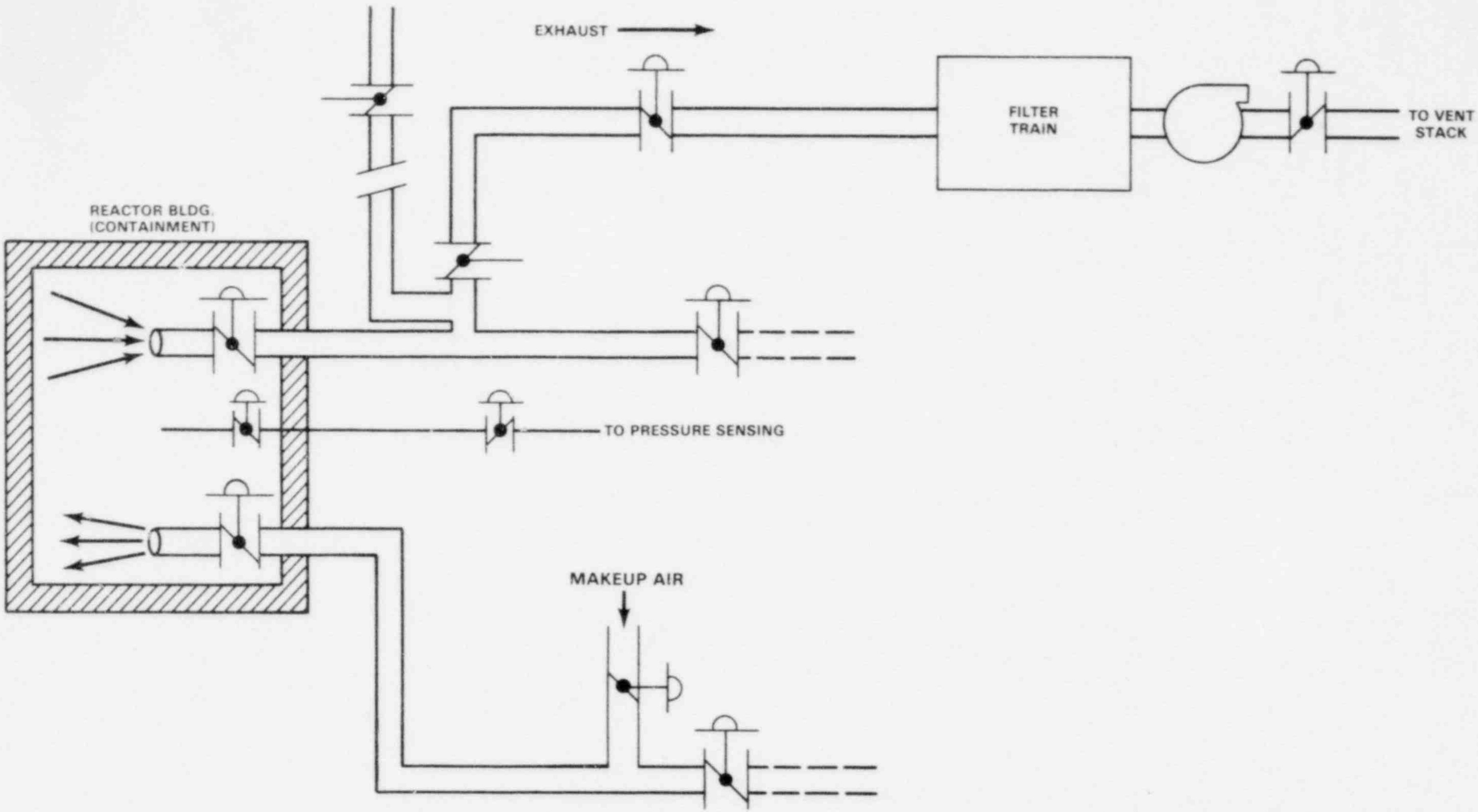


Figure 6.2-1 **Flow Diagram for Purge Using Hydrogen Control Subsystem**

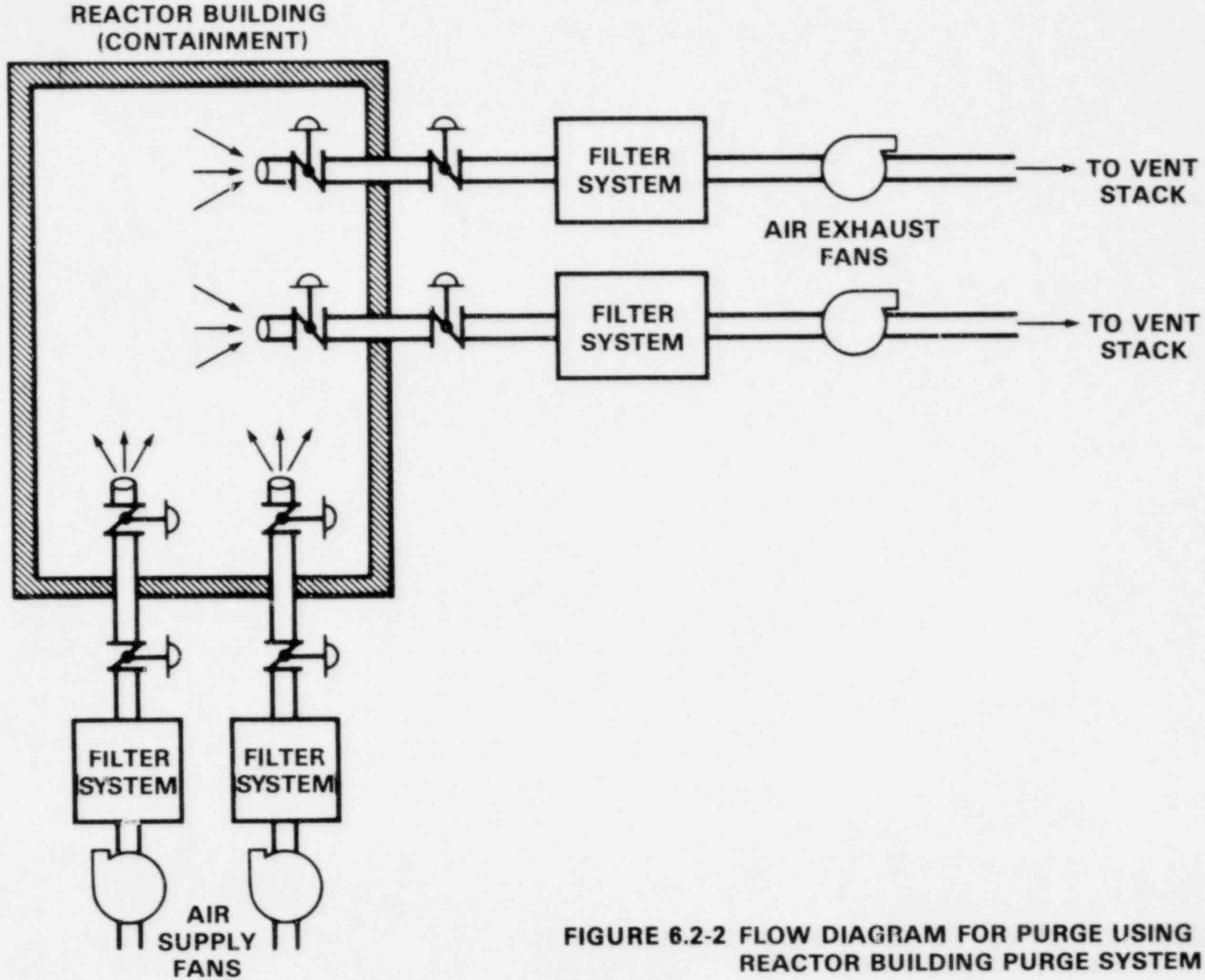


FIGURE 6.2-2 FLOW DIAGRAM FOR PURGE USING REACTOR BUILDING PURGE SYSTEM

The existing pilot plant, however, is not believed, by either the NRC staff or ORNL personnel, to be a practical system for decontaminating the TMI reactor building atmosphere. This small-scale laboratory system was not designed to be portable and is not readily adaptable for use at TMI. Approximately 50% of the hardware, including refrigeration and reversing heat exchanger systems, which would be needed at TMI, are not presently incorporated in the ORNL model. Most importantly, however, the existing pilot plant is unacceptable for use in decontaminating the atmosphere in the reactor building because of this system's very small flow capacity. At 15 scfm it would require nearly three years of continuous processing (i.e., no downtime for repairs and maintenance) to decontaminate the atmosphere to the maxmimum permissible Kr-85 concentration (1×10^{-5} µCi/cm^3) for workers as required by 10 CFR 20 (Ref. 19).

A larger selective absorption system, with the capability to process approximately 150-200 scfm, has also been evaluated by the NRC staff. Although a selective absorption system of this size has never been constructed, it would be expected to effectively remove more than 99% of krypton from the process stream. After passing through the column, the gas stream would flow back to the reactor building. Krypton would be removed from the column in a separate flow stream and transferred to pressurized containers for long-term (100 years) storage. The krypton removal may be accomplished by either a bleed-and-feed process or by continuous operation. A system designed to process 150-200 scfm, if operated continuously for about two months, would reduce the amount of Kr-85 in the reactor building atmosphere to less than 0.1% of its current inventory. We estimate that processing about 23,000,000 ft^3 of gas (11.5 reactor-building volumes) would be required to reduce the krypton level in the reactor-building gases to the maximum permissible concentration of Kr-85. This would require approximately three months of continuous processing.

The absorption system is based on the property of a fluorocarbon, namely dichlorodifluoromethane, or Freon 12, to selectively absorb noble gases. The process has been integrated into a single combination column with supporting equipment, as shown in Figure 6.3-1. Contaminated gases are withdrawn from the reactor building, dehumidified, filtered, compressed to approximately 125 psig, and cooled to near -30°F. The gas would then be fed into the absorption section of the combination column and contacted countercurrently with the downflowing liquid freon solvent. The solvent containing the dissolved Kr-85 would subsequently flow into the intermediate and final stripper sections of the column. The reboiler at the bottom of the column would operate at 104°F and 125 psig. The solvent from which the Kr-85 has been removed would be cooled to -30°F before it would be pumped back to the top of the column. Trace quantities of water and iodine may be removed from this solvent stream by a molecular sieve and/or silver-impregnated zeolite prior to recycling. The decontaminated gas would then leave the top of the column. Decontaminated gases may contain 5 to 10% Freon 12, and would, therefore, be passed through a turboexpander and a molecular sieve bed (a filter) to recover solvent. The decontaminated gas would then be recycled into the reactor building until the Kr-85 concentration reached allowable limits.

The concentrated krypton waste gas would be compressed and placed in high pressure cylinders for storage. The cumulative waste gas collected from processing the contents of the reactor building could be stored at 2000 psig in a few standard gas cylinders. The internal volume of one standard gas cylinder is 1.54 feet^3. The krypton activity in a cylinder will necessitate radiation shielding (approximately one inch of lead) and some cooling. Alternatively, the krypton gas could be stored at lower pressure (and with lower risk of leakage) in a larger number of these cylinders. Onsite storage is discussed in Section 6.8 and transportation and, burial or release of krypton in a remote location are discussed in Section 6.9.

Members of the NRC staff with extensive nuclear construction experience estimate that it would require at least 16 months* to make a scaled up selective absorption system, capable of processing 150-200 scfm, into operation

*ORNL personnel have estimated that a minimum of 13 months would be required on a "best effort" schedule for making a 150-scfm system operational at TMI. This estimate includes no contingencies and several simplifying assumptions (Ref. 23). A more optimistic schedule of 6 months has also been estimated by a Congressional staff aide (See Section 9.0).

at TMI. This estimate is based on such considerations as personnel mobilization and organization (including engineers and construction workers), system design, component procurement, system fabrication, site coordination (including construction of a building to house the system), and system testing prior to operation. As a "best effort" estimate, this schedule assumes that competitive bidding for equipment would not be used and that the design criteria (Ref. 22) for the system would be the minimum required for radwaste systems built at nuclear power facilities. These criteria establish the minimum acceptable requirements for quality assurance, seismic design, component quality classification, and preoperational testing. This estimate, although recognizing that some necessary equipment may be available "off the shelf" assumes, based on experience, that procurement of other equipment will take approximately 3-4 months. It should be noted that even where equipment is available it will be necessary to determine where it is located, whether it is functional, what maintenance will be necessary prior to operation, and whether it is compatible with the system design (i.e., can components be connected based on capacity and available connections).

6.3.3 Occupational Exposure

The occupational radiation exposure at the Oak Ridge pilot plant has been negligible. It is anticipated that the exposure would increase slightly with a larger system. The feature that sets personnel exposure during system operation and maintenance is the volume of krypton contained within the process at any one time. Shielding would be provided for components having a high-radiation field. For major maintenance activities, krypton can be completely removed from the absorber system to further reduce exposure. We estimate that an occupational exposure of about 25-50 person-rem would result from operation of this system including filter removal. If a decision were made to store the krypton onsite, the storage system would be designed for remote operation; however, it would be unrealistic to assume that the storage system would not require some maintenance and surveillance during the approximately 100 years while the Kr-85 decays. This would result in an additional estimated occupational exposure of 90-170 person-rems. As discussed in Section 6.9, the occupational exposure resulting from a decision to transfer the gas for offsite disposal (i.e., handling and packaging of the gas for transport) would result in an occupational exposure of 8-24 person-rems.

6.3.4 Environmental Impact

Selective absorption has zero release as a goal. Krypton is removed from the reactor building and stored in pressurized containers with only minimal release to the environment, although some leakage is expected. In addition, a few cubic centimeters would be released each time gas cylinders are changed. Subsequent long-term storage of the pressurized containers on site will not affect the environment directly; however due to possible corrosion of the storage containers with time the potential for accidental release would remain while the Kr-85 is stored on site (see Section 6.8).

6.3.5 Accident Analysis

For the purpose of analyzing potential accidents, the absorption process system and pressurized storage containers will be reviewed separately.

(1) Absorption Process

The maximum curie content in the absorber system (12-inch column) at any one time would not exceed 200 Curies. Process components will be housed in a confinement structure. Automatically activated isolation valves would be used to separate the absorber from the reactor building and the gas storage system whenever a malfunction is detected. Assuming an accident which results in a release of the entire process inventory of krypton (200 Curies) to the confinement structure and subsequently to the environment over a 2-hour period, the resulting total-body gamma dose at the site boundary would be 0.1 mrem and a beta skin dose of 6 mrem assuming a X/Q of 6.8×10^{-4} sec/m^3.

(2) Gas Storage

The process product, concentrated krypton gas, could be stored onsite in pressurized containers. Numerous container configurations can be designed. For a bounding calculation the staff has asumed that all 57,000 Curies of krypton are stored in one container. If that container ruptured, a release of the krypton to the confinement structure and subsequent releases to the environment over a two-hour period would result in a total-body gamma dose at the site boundary of 20 mrem and a beta skin dose of 1700 mrem, assuming a X/Q of 6.8×10^{-4} sec/m^3. This calculated total body dose is a small fraction of the limits set forth in 10 CFR Part 100 (Ref. 15). There are no skin dose limits in 10 CFR Part 100.

Summary

The selective absorption process has been studied and has had extensive development on a small scale. Large-scale operation has not been proven, but all signs indicate that the absorption system would perform satisfactorily to remove krypton from the TMI reactor building atmosphere. The existing pilot plant at ORNL is not portable and does not incorporate all of the components which would be needed at TMI. The pilot plant, because of its small flow capacity, would require more than three years to process the building atmosphere to the maximum permissible concentration of Kr-85. The NRC staff's "best effort" estimated time required to construct a scaled-up (150-200 scfm) absorption system at TMI is at least 16 months, but a longer time may be needed, depending on the number and complexity of problems that could arise during the design, procurement, construction, testing, or operation phases of such a project. Based on prior operating experience, the occupational exposure due to processing should be very low. Doses to the public would be neglibible since only minimal leakage of Kr-85 from the system itself is expected. The estimated occupational exposure resulting from extended onsite storage is 90-170 person-rem. (See Section 6.8.) See Section 6.9 for a discussion of transportation and offsite disposal. Worst case accident scenarios do not result in threats to public health and safety.

6.4 Charcoal Adsorption Systems

6.4.1 Introduction

The following discussion presents the NRC staff evaluation of a nonregenerative charcoal adsorber system. This system is similar to those used in boiling water reactor (BWR) off-gas treatment systems which are routinely used to retain noble gases for decay prior to their release to the environment. The staff evaluated both the ambient temperature and refrigerated charcoal adsorber systems. Both systems would require extremely large volumes of charcoal; the ambient system would require 34,000 tons and the refrigerated system 12,000 tons. Both charcoal systems when operating normally would have no releases associated with them; however, during anticipated operational occurrences minor releases can be expected. Since noble gases do not react chemically with charcoal, long-term surveillance would be required.

A regenerative charcoal adsorber system was proposed in a public comment. The NRC staff has determined that this proposal is not feasible and it is not recommended. A discussion of this proposal is contained in Section 9.5.16.

6.4.2 System Description and Operation

Ambient Charcoal System. The transfer of radioactive airborne activity from the reactor building to the ambient charcoal system would follow the same flow-path described for the purge system. The radioactive airborne activity from the reactor building atmosphere will contain moisture. If the charcoal in the adsorber system is exposed to humidity in excess of 3%, the charcoal would lose its capacity to adsorb krypton. The major fraction of the moisture would be removed as the airborne activity passed through the cooler condenser. Additional moisture removal could be accomplished by passing the gas through a dessicant dryer. In the event of an operational upset, where excessive moisture or other gases would pass through the moisture-removal equipment, a guard bed or tank could be used to protect the main charcoal bed. The usual guard-bed volume is 2 to 3 ft^3. The main charcoal beds would consist of tanks containing charcoal, which would be arranged in 45 rows of 10 tanks per row. Storage tanks rather than piping would be used to facilitate initial loading of the charcoal. If breakthrough occurred in a bed, the bed would be isolated and used to store the Kr-85. Based on staff calculations, approximately 34,000 tons of charcoal would be required to absorb the krypton in the Unit 2 reactor building atmosphere. The tanks would require manholes on the top for loading of the charcoal. Each tank would have isolation valves manually operated to isolate the tank and remove it from service. Figure 6.4-1 provides a flow diagram of the ambient charcoal adsorber system.

Based on shop-fabricating capabilities and on shipping considerations, the maximum tank size would be 12 feet in diameter and 50 feet in length. The system would require 450 tanks. Housing the tanks would require a building 700 feet long, 150 feet wide, and 60 feet high. Figure 6.4-2 provides the conceptual layout for the building to house the charcoal system.

Refrigerated Adsorber System. The transfer of radioactive airborne activity from the reactor building to the refrigerated charcoal adsorber system follows the same path as that for the ambient system. The refrigerated system offers the benefit of increasing the adsorption coefficient by a factor of from 2.5 to 3 compared with the ambient system. The increased adsorption coefficient reduces the volume of charcoal required by the same factor. Therefore, a refrigerated charcoal adsorber system would require approximately 12,000 tons of charcoal.

However, the advantage gained by reduced charcoal volume is offset by increased system complexity. A malfunction of the refrigeration equipment could cause system shutdown for maintenance. A vault would have to be constructed and maintained at 0°F with a mechanical refrigeration unit to cool the charcoal and to house the tanks. The system design must be capable of withstanding loss of cooling and corresponding pressure buildup. The staff estimates that it would take from 2 to 4 years to design the system, procure needed materials, fabricate the system and building to house it, and to perform preoperational tests.

6.4.3 Occupational Exposure

The design criteria for both the ambient and refrigerated charcoal adsorption systems would include features to maintain occupational exposure "as low as reasonably achievable." Since the charcoal adsorption systems are designed for full noble gas retention on charcoal beds, the onsite total body dose has been calculated to be approximately 47 person-rems. This total body dose is based on anticipated maintenance and surveillance during processing and storage.

6.4.4 Environmental Impact

A properly operating charcoal adsorber system would fully treat and store the Kr-85 in the reactor building atmosphere. Therefore, the radiological impact of a normally operating charcoal adsorber system would have no offsite dose effect.

6.4.5 Accident Analysis

Ambient Charcoal System. This system would require 450 tanks of charcoal. The radioactive content of each sucessive tank would decrease as the concentration of Kr-85 in the reactor building decreases. The tank with the highest activity would contain 1430 curies. Assuming that the charcoal isolation valve for this tank fails and the entire 1430 curie inventory escapes, the staff estimates that the doses at the site boundary to the maximum exposed individual would be 41 mrem beta skin dose and 0.5 mrem total body gamma dose.

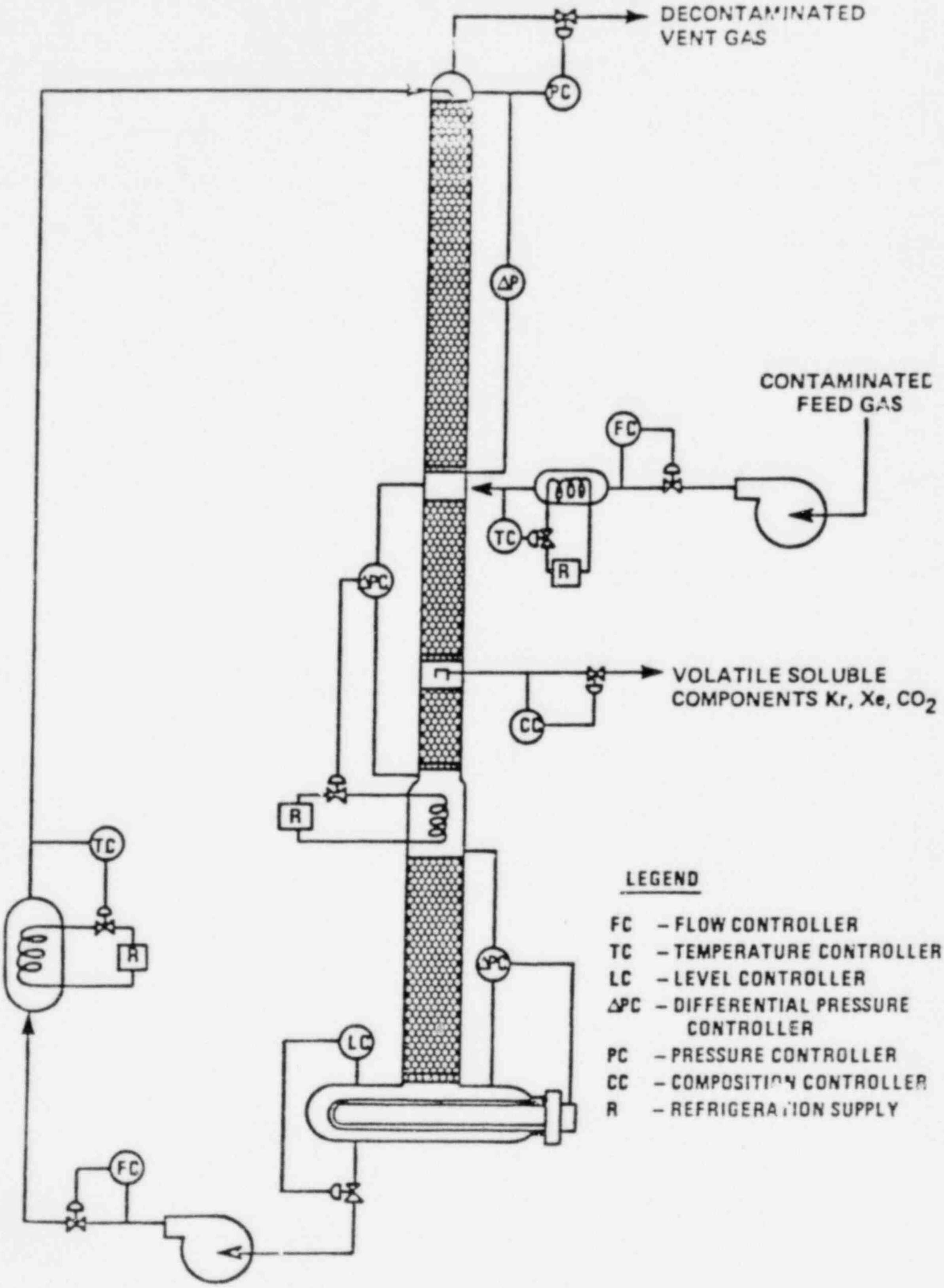


Figure 6.3-1 Schematic of the Combination Column

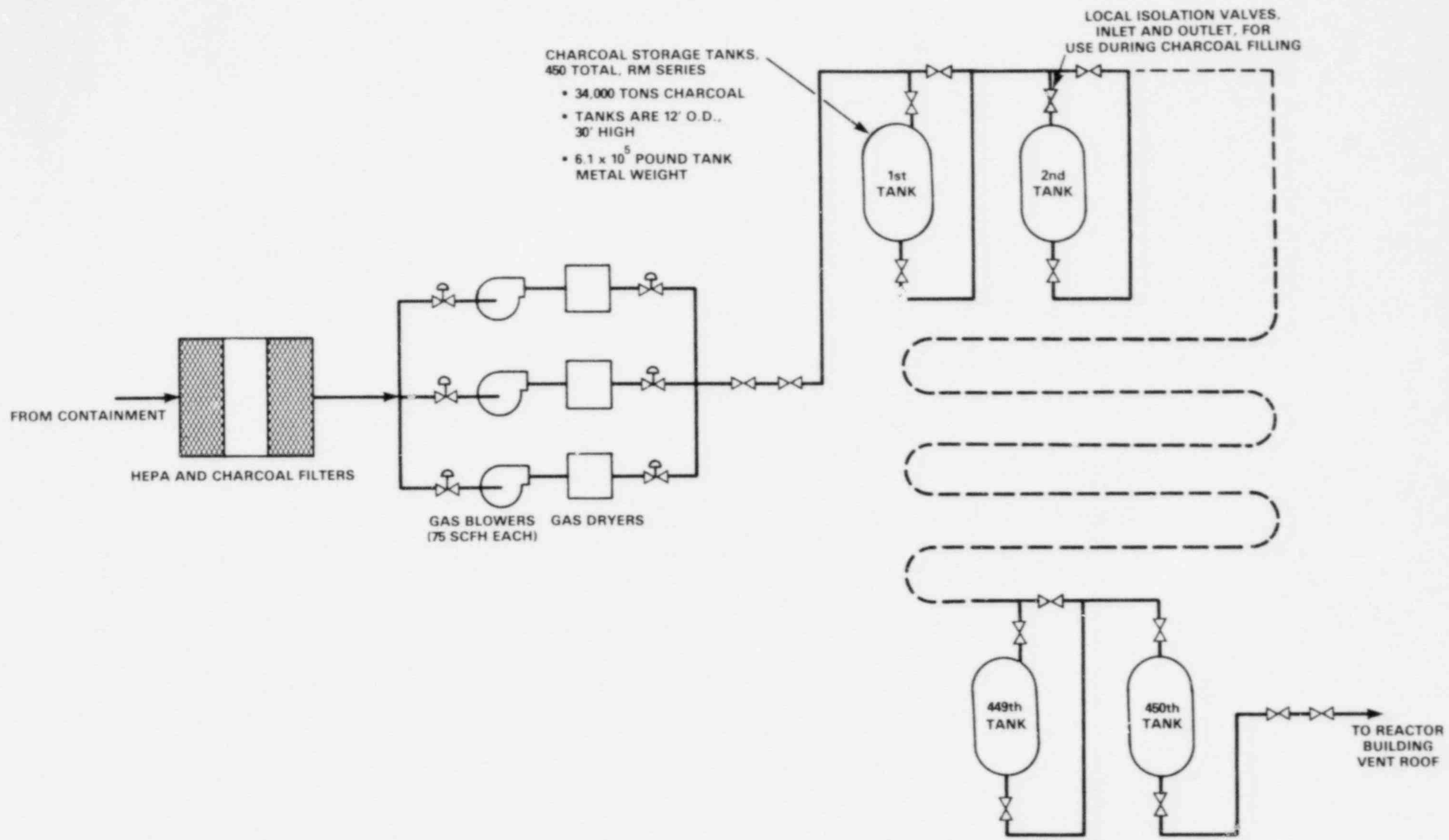
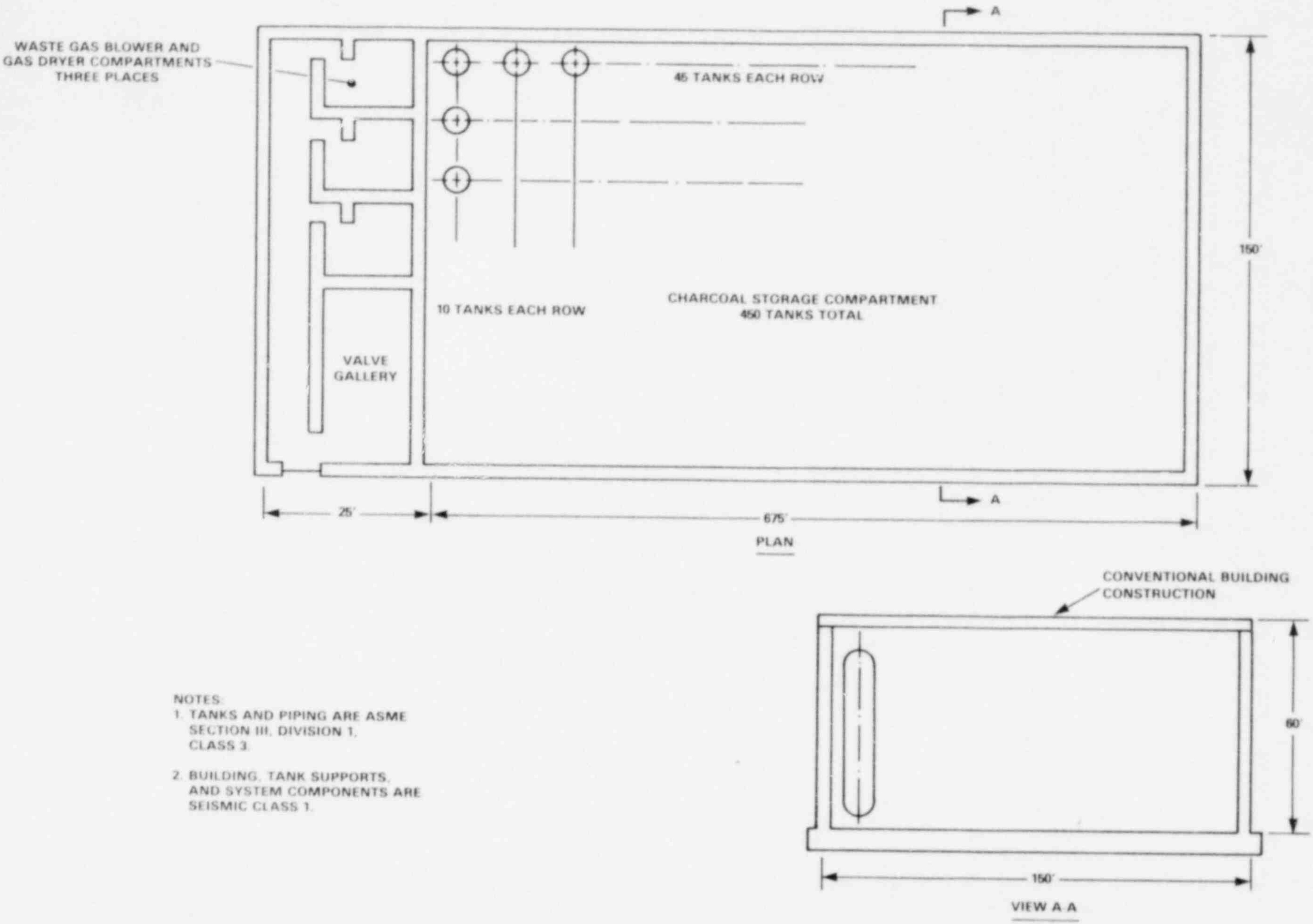


Figure 6.4-1 Flow Diagram for Purge Using Charcoal Adsorption System



NOTES:
1. TANKS AND PIPING ARE ASME SECTION III, DIVISION 1, CLASS 3.
2. BUILDING, TANK SUPPORTS, AND SYSTEM COMPONENTS ARE SEISMIC CLASS 1.

Figure 6.4-2 **Conceptual Layout - Charcoal Storage Arrangement**

Refrigerated Adsorber System. This system would require 150 tanks of charcoal. The radioactivity in each succeeding tank would decrease as the activity in the reactor building decreased. The tank with the highest activity would contain approximately 4300 Curies. If the same accident assumptions are used for this evaluation as were used above, the resulting doses would be increased by a factor of 3. Therefore, a beta skin dose of 124 mrem and a total body dose gamma of 1.5 mrem could be expected.

Summary

It is possible to remove the Kr-85 from the reactor building with either room-temperature or refrigerated charcoal adsorber systems. The primary advantages of the room-temperature charcoal adsorber system are simplicity of operation and the capacity to accommodate extremely radioactive gas mixtures. However, the major disadvantage for a room-temperature charcoal adsorber system is the large volume of charcoal it requires. A refrigerated charcoal adsorber system would reduce the volume of charcoal required. However, to gain a reduction in charcoal volume, an increase in equipment complexity would result. Since the primary form of radioactivity in the reactor-building atmosphere is Kr-85, a noble gas fission product that does not ordinarily react chemically, the charcoal adsorber would function as a physical adsorber to retain the Kr-85. Loaded charcoal beds would then have to remain in storage approximately 100 years to permit radioactive decay of Kr-85 to insignificant levels. The NRC staff has estimated that a charcoal system could be made operational in 2-4 years. This lead time is unacceptable for those reasons discussed in Section 5.0.

6.5 Gas Compression System

6.5.1 Introduction

The gas compression system involves drawing off the reactor building atmosphere into suitable pressurized storage containers so that the entire inventory of Kr-85, remains in pressurized storage for approximately 100 years to permit radioactive decay to insignificant levels. This system would reduce the Kr-85 concentration in the reactor building by feed-and-bleed operation to the maximum permissible concentration of 1×10^{-5} µCi/cc. To accomplish this, approximately 23 million cubic feet (11.5 reactor-building volumes) would have to be processed by the system.

The staff has received a number of letters from the public suggesting alternatives to the onsite purging of the Kr-85 gas. Included were suggestions for compression and storage of Kr-85 and offsite shipment with subsequent release at a remote site. Transportation and offsite disposal of Kr-85 are discussed in Section 6.9. Additionally, comments on gas compression alternatives are addressed in Section 9.0.

6.3.2 System Description and Operation

The gaseous contents of the reactor building would be transferred to pressurized gas containers for long-term storage. The containers can be designed in various pressure/volume combinations to accommodate the reactor-building gases.

To reduce activity in the reactor building to maximum permissible concentrations, a total of 11.5 reactor building volumes (23 million cubic feet) would be transferred to storage. The compressed gas train would include gas dryers, a charcoal adsorber, a HEPA filter, three gas compressors, storage containers, and associated piping and valves. Figure 6.5-1 provides a flow diagram of the system. The compressed gas would remain stored on the site for approximately 100 years to allow the Kr-85 to decay to insignificant levels. The minimum volume for the storage system would result if the gas were stored at the highest possible pressure. The practical upper pressure limit for gas storage is 2500 psig. At this pressure, 80,000 standard gas bottles (1.54 cubic feet) would be needed to store the gas. An alternative to extended onsite storage would be to package the gas for offsite disposal. This alternative is discussed in Section 6.9. At the other end of the spectrum is a large-volume, low-pressure storage system. For example, if a container the size of the existing reactor building were constructed, the gas could be stored at 170 psig.

The General Public Utilities Corporation (GPU) contracted with MPR Associates to investigate the most practical means for storing the compressed gas (Ref. 21). MPR recommended a low-pressure storage system in which the gas would be stored at 340 psig in 36-inch outside-diameter standard-wall pipes. One million cubic feet of storage volume would be required, which would be equivalent to 150,000 linear feet, or 28 miles of pipe. The proposed pipe storage complex is divided into two major sections (high activity and low activity) to minimize shielding requirements. The high-activity piping section would include 20% of the piping and would contain 90% of the Kr-85. The high-activity section would be segregated into five units to limit Kr-85 releases in the event of leakage and to optimize inherent shielding. Low-activity pipe units would be placed to the outside of the storage area to act as a shield for the highest activity units in the center. The building to house the high-activity piping, the filters, dryers, and gas compressors, would be 260 feet long, 90 feet wide, and 30 feet high. Six inches of concrete shielding around the high-activity piping would be required. The low-activity pipe section would contain 80% of the total piping and 10% of the Kr-85. The building for housing the low-activity piping would be 220 feet long, 160 feet wide, and 60 feet high. It would require no shielding.

6.5.3 Occupational Exposure

No significant amount of radiation exposure should be incurred by plant personnel during operation of the gas compression system. All system components are relatively simple and should require minimal maintenance during gas processing. Should maintenance be required, most components could be isolated and purged to decrease radiation exposure during repairs. The staff estimates an occupational exposure of approximately six person-rems during operation and maintenance.

Periodic maintenance of the long-term storage system is a potential source of occupational exposure. Although a system can be designed for maintenance-free operation, it would be unrealistic to assume that some maintenance would not be necessary during the approximtely 100 years of storage required. The staff estimates that surveillance and maintenance during long-term storage would result in an occupational exposure of approximately 42 person-rems.

6.5.4 Environmental Impact

Krypton-85 can be removed from the reactor building and stored in pressurized containers with minimal release to the environment. The resulting doses to the public due to the anticipated minor releases would be insignificant.

Although subsequent long-term storage in pressurized containers onsite will not affect the environment directly, the potential for accidental releases will remain for over 100 years as the stored Kr-85 decays.

6.5.5 Accident Analysis

The gas compression process was analyzed for its radiological consequences following an accidental release of compressed gas from the storage system. The radiological consequences of a failure in the feed train were not analyzed since it was assumed that the feed process would be isolated well before the accidental release approached a magnitude which would equal a release following a storage-system failure. The accidents analyzed therefore, represent the most severe occurrences with respect to their potential exposure potential at the site boundary. Analyses were performed on accidental releases from several storage configurations.

Assuming the compressed gas storage system is segregated into four units, postulated unit failure with a subsequent release of 14,250 Curies to the environment in a two-hour period would result in a site boundary total-body gamma dose of 5.0 mrem and a beta skin dose of 410 mrem assuming a conservative X/Q of 6.8 x 10^{-4} sec/m^3. The total body gamma dose is a small fraction of the limit set forth in 10CFR Part 100 (Ref. 15); 10CFR Part 100 does not include a limit for beta skin exposure.

Summary

The gas compression system offers several advantages. The gas compression system is essentially a "zero release" system which could be operated to decontaminate the reactor-building atmosphere with insignificant environmental impact. The occupational exposure resulting from operation and long-term surveillance of the system is estimated to be 41 person-rems. The major disadvantages of the gas compression system is the extensive time required to build and install the system (25 to 35 months). The NRC staff considers this time period unacceptable for the reasons discussed in Section 5.0.

6.6 Cryogenic Processing System

6.6.1 Introduction

A potential means of decontaminating the contaminated reactor-building atmosphere is through the use of a cryogenic processing system. The operating principle of the cryogenic processing system is the condensation of Kr-85 from the incoming air by direct contact with liquid nitrogen (boiling point, -195.8°C). The liquefied Kr-85 would be allowed to concentrate and would then be vaporized and transferred to an onsite storage facility for subsequent disposition. Use of the liquefaction or cryogenic processes has been recommended by various members of the public.

The NRC staff has evaluated the availability of an existing cryogenic processing system (CPS) at a commercial boiling water nuclear power plant to decontaminate the reactor-building atmosphere. The cryogenic system has never been placed into operation and is being offered for sale by its current owner because of anticipated high operating costs and the degree of continued maintenance that the unit would require. Although the system is available for purchase and use by the licensee, the erection of a new building would be required to house the system because of the need to confine anticipated leakage from the CPS. The building would be approximately 110 feet long by 72 feet wide and would vary in height from 20 feet to 35 feet.

6.6.2 System Description and Operation

If installed, the cryogenic system would connect with the reactor building through the existing hydrogen-control system. The contaminated air from the reactor building would be transported to the cryogenic processing system in the adjacent building after passing through the HEPA filters and charcoal adsorber of the hydrogen control system.

The cryogenic processing system consists of three processing trains. The major components of each train are the prefilter, catalytic recombiner, aftercooler, and cryogenic treatment subsystem. The three processing trains are supported by a hydrogen storage system, a liquid-nitrogen storage system, and a noble-gas storage system. A flow diagram of the cryogenic processing system is shown in Figure 6.6-1. The cryogenic processing system can process air from the reactor building at a flow rate of approximately 225 scfm. After passing through the HEPA filters and charcoal adsorbers of the hydrogen control system for removal of trace quantities of airborne radioactive particulates, the air from the reactor building would be heated in the CPS preheater prior to injection into the CPS catalytic recombiner for oxygen removal and corresponding volume reduction of the recombiner effluent. The effluent gas from the recombiner would then be cooled in a downstream aftercooler and directed to the cryogenic

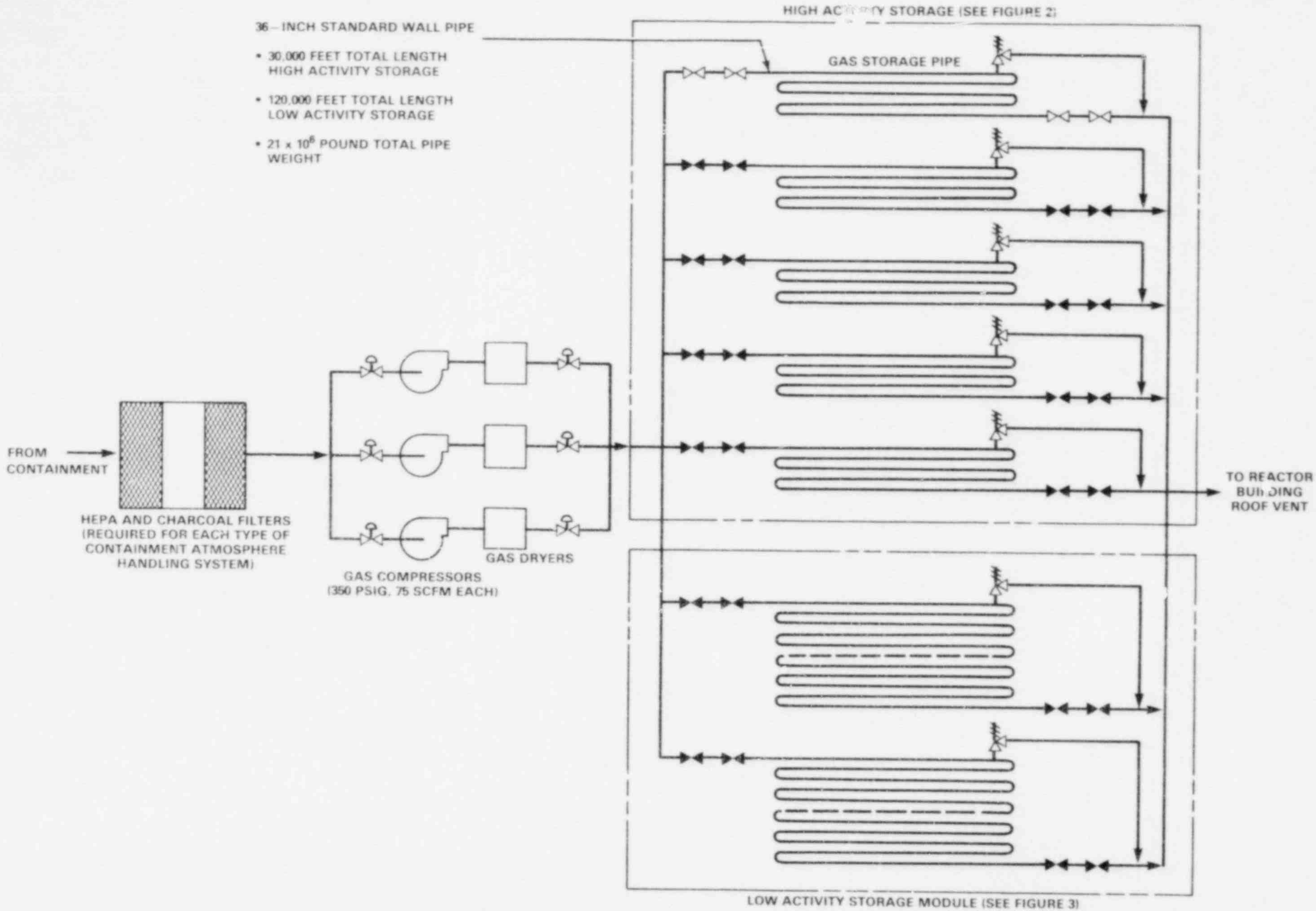


Figure 6.5-1 **Flow Diagram of Gas Compression System**

treatment subsystem (CTS). The major components of the CTS consist of two feed compressors, a gas preheater, a trace recombiner, an aftercooler, a separator, three prepurifiers, a cooldown heat exchanger, a removal column, a condenser heat exchanger, a phase separator, a decay column, a hydrocarbon conversion unit, and an ambient heater. (A flow diagram of the cryogenic treatment subsystems is shown in Figure 6.6-2.)

The effluent gas from the CPS aftercooler would enter the suction side of the CTS feed compressors. The feed compressors would transport the gas through the preheater, trace recombiner and aftercooler for gas heating, removal of trace quantities of oxygen, and gas cooling, respectively. Moisture would be removed from the cooled gas in a downstream separator. The gas would then enter the prepurifier for removal of carbon dioxide and any remaining moisture. The purified gas would then enter the cooldown heat exchanger to reduce the gas temperature to approximately -29°F. The chilled gas would enter the removal column where the methane and noble gases (essentially Kr-85 and stable krypton, xenon, and argon) would be removed by condensation from counterflowing liquid nitrogen to collect in a pool at the bottom of the removal column. At periodic intervals, the condensed methane and noble gas pool would be vaporized and removed from the column via the CPS product compressor and compressed into storage vessels for onsite storage at ambient temperatures. See Section 6.8 for a discussion of onsite storage. The licensee estimates that it would take from 20 to 30 months to put the system into operation. From consultations with construction engineers at Oak Ridge National Laboratories and in the nuclear industry, the staff estimates that it would take a minimum of 20 months to get any CPS operational.

6.6.3 Occupational Exposure

Of all the alternative systems considered for the decontamination of the reactor building atmosphere, the CPS is the most complex in that it consists of more and varied components than the other systems and is expected to require a greater degree of maintenance during operation. In addition, the system operates at positive pressure (85 psig) so leaks must be considered as an anticipated operational occurrence. If leakage from the system occurred downstream of the CTS removal column, that leakage would contain highly concentrated Kr-85 (that is, at least three orders of magnitude higher than in preceding portions of the system). Therefore, the exposure to workers operating and maintaining the CPS is anticipated to be greater than that of any of the other treatment alternatives. The licensee estimates the exposure to workers due to processing, maintenance, and required surveillance activities during long-term onsite storage of the Kr-85, would be approximately 570 person-rems. Most (approximately 90%) of this estimated exposure would occur because of surveillance activities (inservice inspection of components, maintenance, and sampling) associated with the long-term storage of Kr-85. The staff, however, does not agree with the licensee's estimates of the frequency and dose rates that could be encountered during surveillance activities nor with licensee estimates that exposure to workers would be in the range of 137 to 255 person-rems. The staff's lower estimate is based on the emphasis that would be placed on maintaining inplant exposure ALARA and on the assumption that workers would spend less time in high-dose-rate areas than the licensee has estimated. The licensee agrees that extra steps could be taken during design, engineering, and construction stages to reduce worker exposure; however, they state that such changes would significantly extend the 20- to 30-month perio estimated for implementation of the CPS. The NRC staff believes that if ALARA concepts are implemented in the ini.ial engineering and design efforts for the facility, the schedule would not be significantly extended.

6.6.4 Environmental Impact

The CPS, designed for a removal efficiency of 99.9% is not, therefore, a "zero-release" system. During the estimated 2-1/2 months that would be required to process the reactor-building atmospshere, approximately 60 curies of Kr-85 would be discharged in the purified gas effluent from the system. In addition to this, an unspecified amount of Kr-85 would be discharged to the environment due to anticipated leakage from the system. The staff believes that the CPS can be designed to minimize the environmental impact of uncontrolled leakage by judicious monitoring and rapid system isolation upon indication of an upset condition. In any event, the staff estimates that the environmental impact during normal operation of the CPS would be insignificant (i.e., less than 0.01 millirems beta skin dose and 0.0002 millirems total-body gamma dose, assuming a X/Q of 5×10^{-5} sec/m^3).

6.6.5 Accident Analysis

The CPS was analyzed for the hypothetical worst-case failure of the Kr-85 storage system. This failure assumes the rupture of all gas storage vessels and a corresponding breac of the secondary storage containment structure. Under these circumstances, the entire Kr-85 inventory of approximately 57,000 curies is assumed to be released to the environment over a two-hour period. Based on annual average meteorological conditions, the calculated total-body gamma radiation exposure to a person at the site boundary would be 20 millirems, with a corresponding beta skin dose of 1700 millirems, assuming a X/Q of 6.8×10^{-4} sec/m^3. This calculated total-body dose is a small fraction of the limits set forth in 10CFR Part 100 (Ref. 15). There are no skin dose limits in 10 CFR Part 100.

6.6.6 Air Products and Chemicals, Inc., and MITRE Corp. Systems

The CPS discussed in the preceding section was chosen as a typical cryogenic system that is currently available. This system is designed by Linde Division of the Union Carbide Corporation. Another currently available CPS, which operates by essentially the same principle, is designed by Air Products and Chemicals, Inc. This system also uses the basic two-step process, which consists of hydrogen and oxygen recombination, and then removal and concentration of the radioactive gas by cryogenic distillation.

Yet another CPS was described by the MITRE Corporation. This system proposal, while using the same cryogenic techniques, would include a closed recycle to the reactor building. The proposal states that the system would also employ several other unique features including a normal krypton makeup feed, and a process combination of air separation plant, krypton distillation column, and molecular sieve filter bed to remove the Kr-85. The proposed project schedule totals 11 months, which would allow nine months for procurement, fabrication modifications, and installation, and two months for the startup, debugging, system optimization, and removal of the Kr-85. However, the schedule does not consider the need for a new building to house the system. The NRC staff, based on the discussion in Section 6.6.2, believes this schedule to be an unrealistically short estimate.

Summary

The cryogenic system evaluated here is essentially the same as the other currently available CPS. A difference noted is the addition of a hydrogen supply to the recombiner in the Linde system to further avoid oxygen accumulation. The MITRE system, which includes an air-separation technique and a recycle to the reactor building, would require additional fabrication, and more importantly, may require proof-testing before finalization of a system design.

The primary advantage of each CPS proposed is that the offsite environmental impacts either from operation of the system or from worst case accident scenarios are insignificant. Selection of any CPS as the best alternative is not without its disadvantages, however. First, design, construction, housing, and testing the CPS would result in significant delays in the TMI cleanup effort. From NRC staff consultations with construction engineers at Oak Ridge National Laboratory and in the nuclear industry, we estimate that it would take a minimum of 20 months to get any CPS operational. Second, based on prior experience, operation and maintenance of each CPS would be likely to produce a relatively high occupational exposure. Finally, the onsite storage of concentrated quantities of Kr-85 generated by each alternative would require long-term periodic surveillance and would accordingly represent a continuing risk to workers on the site, as well as to the public.

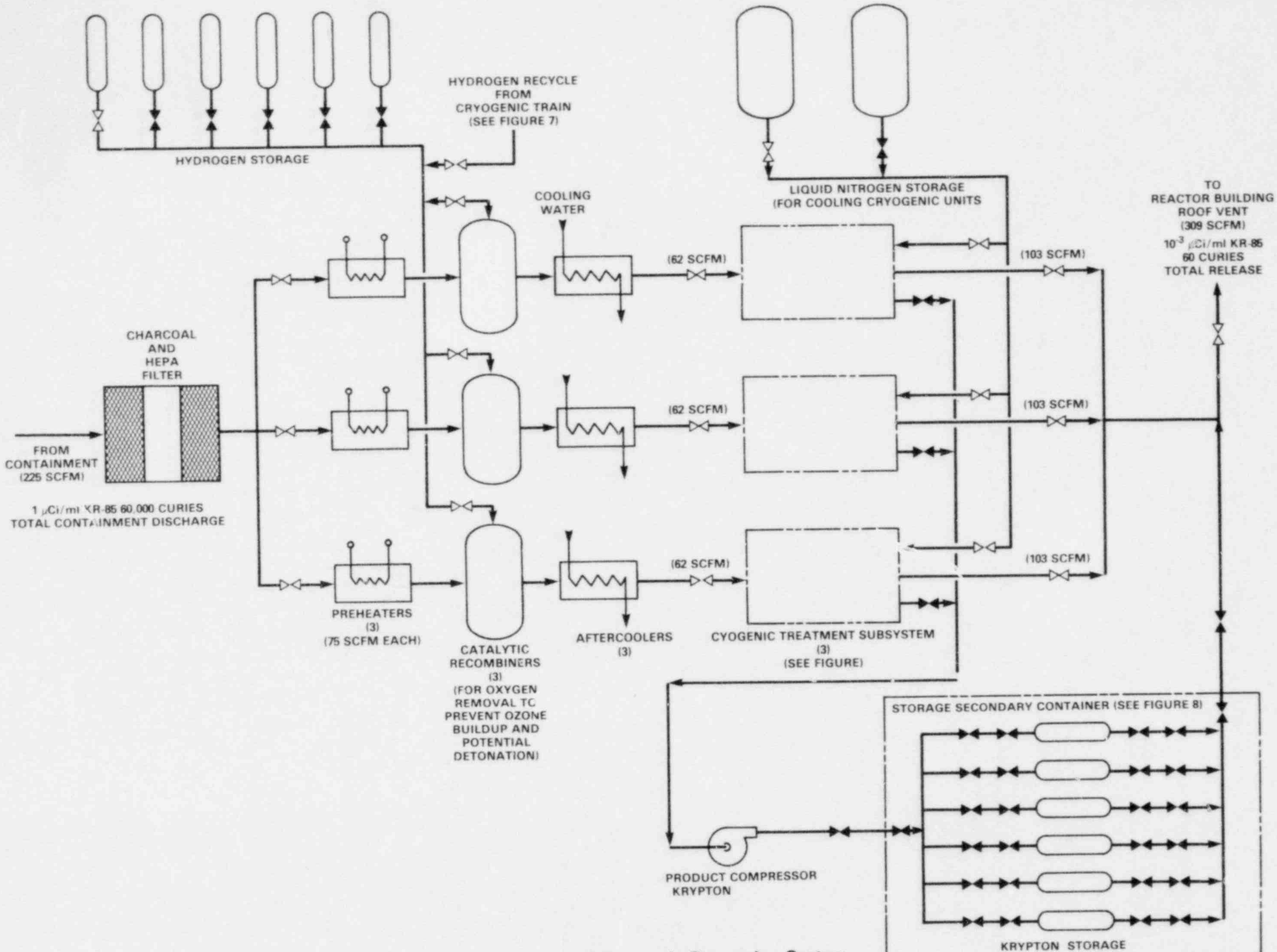


Figure 6.6-1 **Flow Diagram of Cryogenic Processing System**

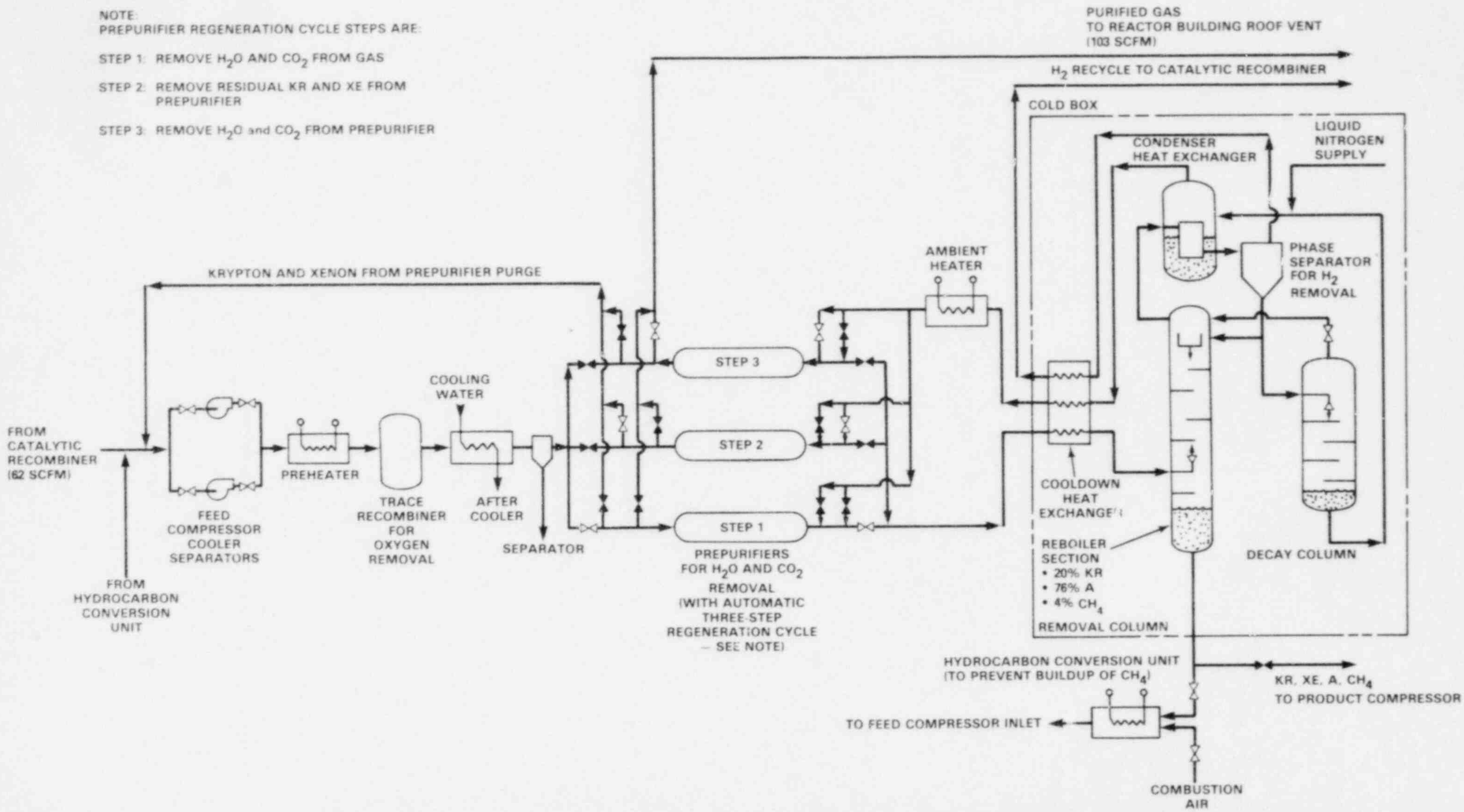


Figure 6.6-2 Flow Diagram of Cryogenic Treatment Subsystem (One of Three)

6.7 Combination Process and Purge Systems

6.7.1 Introduction

The staff has evaluated the feasibility of combining a krypton-recovery system (charcoal adsorption, gas compression, cryogenic processing, or selective absorption) with one of the building-purge alternatives (hydrogen control or reactor-building purge system). This combination method would be performed in two steps. First, a krypton-recovery system (the primary system) would process and contain approximately 95% of the krypton from the reactor building. Then the remaining krypton (approximately 3,000 curies) would be purged to the environment through either the hydrogen control or reactor-building purge system (the secondary system).

The chief advantage of this alternative is the shortened time period, relative to the alternatives discussed in Sections 6.3-6.6, which would be required to implement it. This advantage results from smaller scale processing system requirements. If a 95% Kr-85 removal efficiency is desired with the primary system, approximately six million cubic feet of contaminated air will have to be processed before purging could proceed. In order to process this volume within approximately two months (comparable to slow purge time) the primary system would require a flow capacity of 75-100 scfm. This, primary system used in combination with purging would require flow or storage capacity (if gas compression is chosen as the primary system) approximately 25-33% of the capacity requirement for full-scale krypton-recovery systems described within this assessment.

The staff has estimated a schedule for making a combination alternative operational. The two primary systems that could be operational in the least time are the cryogenic processing system (CPS) and the selective absorption system (SAS). The staff estimates that the minimum times for a full-scale CPS or SAS to be operational are 20 months and 16 months, respectively. The charcoal-adsorption system and gas-compression systems would require a minimum lead time of 24 months for full-scale system availability and would represent a major construction effort. Even scaled-down, charcoal adsorption (e.g., 3000 tons of refrigerated charcoal) or gas compression (e.g., 7 miles of 35-inch OD pipe storage) systems represent relatively impractical alternatives compared to the CPS and SAS.

6.7.2 System Description

In the NRC staff's estimation, a scaled-down CPS would consist of one 75-scfm processing train (as opposed to three trains in the full-scale system). The remainder of the CPS, including the noble gas storage system, would remain essentially as designed for the full-scale system (see Section 6.4.2). The staff estimates, based on the construction of a small building for a CPS with one processing train, that the lead time for the CPS might be reduced, as compared to full scale, by as much as 4 months. Thus it would still take approximately 16 months to make a small-scale CPS operational and an additional two months to process the first six million cubic feet of contaminated air. At least another month would be required for purging, assuming summer/fall meteorological conditions (see Section 6.2), to reduce the reactor building concentration of Kr-85 to below maximum permissible concentrations of Kr-85 (that is, less than 1×10^{-5} μCi/cc).

The full-scale SAS described in Section 6.3 would require the capability of processing several hundred standard cubic feet per minute of reactor-building air, whereas, the scaled-down SAS would be required to process from 75 to 100 scfm. Thus, the scaled-down system could consist of a single train and feed components (dryer, compressor, cold trap, and molecular sieve) and a lower flow capacity absorption column. The requirements for the noble gas storage system would remain unchanged but the overall building requirements would be smaller than needed for the full-scale system. The staff estimates that the lead time for the small-scale SAS might be reduced by as much as four months. Thus it would still take a minimum of 12 months to get a small-scale SAS operational, followed by several months of system operation and at least one month for subsequent reactor-building purging.

These estimates for anticipated lead times for scaled-down cyrogenic processing and solvent absorption systems are based on the simplest designs and assume little or no redundancy (for increased reliability) in system components. These estimates also assume minimum standards in regulatory requirements (Ref. 22) for building and system quality and seismic classification. Thus the schedules for a combination method do not reflect allowances for regulatory requirements which may be recommended as the result of a detailed staff review of a licensee proposal for such a method.

6.7.3 Occupational Exposure

The occupational exposures that could result from implementation of this alternative range from 115-255 person-rem (depending on the selection of either the SAS or CPS as the primary system) and are discussed in Sections 6.3.3 and 6.6.3.

6.7.4 Environmental Impact

The environmental dose impact associated with this alternative (assuming 5% of the reactor-building atmospheric inventory of Kr-85 is purged) would be approximately 1/95 (0.01) of the impact associated with the slow purge alternative discussed in Section 6.2. This would present negligible public health risk (See Section 7.1.)

6.7.5 Accident Analysis

The accident analyses described in Sections 6.3.5 and 6.6.5 would apply to this alternative. The resulting total-body and beta skin dose to the maximum exposed individual are estimated to be 20 and 1700 mrem, respectively.

Summary

The staff's evaluation shows that the "combined" alternative method can reduce the lead time for system availability by as much as 25%. Nevertheless, the minimum time frame to make this method operational is one year and, for the reasons outlined in Section 5.0, represents an unacceptable delay in the decontamination of the reactor-building atmosphere.

6.8 Onsite Long-Term Storage of Krypton-85

All alternatives proposed for removing the Kr-85 gas, other than by reactor-building purge or disposal offsite (see Section 6.9), require provisions for a long-term storage facility on site (for approximately 100 years to allow for radioactive decay). See Section 6.9 for a detailed discussion of the transportation and offsite disposal of radioactive gases.

The existing technology for storing Kr-85 is limited. Table 6.8-1 provides an assessment of different storage techniques.

Although shallow land burial is a common disposal method at the commercial low-level waste facilities, the NRC staff is opposed to bur[illegible] of any radioactive waste at Three Mile Island because of the potential for subsequent release to the environment. Thus onsite gas storage in an engineered facility remains as the only practical alternative, even though this type of storage has not been perfected. For example, container corrosion is a major problem that can be caused by collected gas impurities such as oxygen or nitrogen oxide, and water. Also, rubidium, the decay product of Kr-85, may combine with oxygen to form Rb_2O. The long-term corrosion effects of Rb_2O in pressurized storage containers of Kr-85 are not known. Thus further study and staff evaluation would be necessary if a Kr-85 disposal method were chosen that required long-term storage.

Table 6.8-1. Comparison of Krypton-85 Containment Techniques*

Technique	Development status	Advantages	Disadvantages
Low-pressure tanks	Feasibility studies performed; no field tests	Low pressures with low peak probability	Very large storage volume; ozone removal required; radiolytic product corrosion unknown
High-pressure cylinders	Used for shipment at ICPP; no long-term tests	Low-storage volumes; long technical background	Long-term corrosion unknown; high pressures increase probability of massive release; secondary containment required
Adsorption on charcoal	Development data completed; short-term operation	Reduces vapor pressures of containers	Large storage volume; fire and explosion hazard
Encapsulation (include solid matrix entrapment e.g., clathrates)	Laboratory studies only partly completed primary containment	Reduces vapor pressures of containers; provides process technically difficult	Effects of radiation, temperature, and corrosion need extensive study;
Engineered storage facility	Cost and feasibility studies continuing; no field experience	Protection from environment, earthquakes, and gas leaks; secondary containment and recovery of leaked gases	Delay in TMI cleanup

*Adapted from T. R. Pinchbacks, "Materials Screening Test for the Krypton-85 Storage Development Program, "EG and G, CR EY-76-c-07-1570, January 19, 1979.

6.9 Transportation and Offsite Disposal

6.9.1 Discussion

The implementation of the Cryogenic Processing System alternative, Selective Absorption Process System alternative, or Gas Compression System alternative (using high pressure standard gas cylinders) would result in contained inventories (57,000 Ci) of Kr-85 which would be stored onsite to permit radioactive decay. Based on the half-life of 10.7 years for Kr-85, it would take approximately 100 years for the krypton to decay to insignificant levels. An alternative approach to extended storage of the gas at TMI would be to transfer the gas to DOT and NRC approved containers for transportation and offsite disposal.

The staff has considered several alternatives of disposing of the Kr-85 at an offsite location. The alternatives include transport to a commercial low level waste burial ground (for burial) and transport to a remote location (e.g., a desert) for release to the environment.

6.7.2 Environmental Impact

There are three commercial low-level waste burial grounds currently in operation, located in Barnwell, South Carolina; Beatty, Nevada; and Richland, Washington. However, the State of South Carolina has imposed a ban on shipments of waste from TMI Unit 2, leaving only the two Western sites as potential receipients of gas-filled containers of Kr-85 from TMI. Each site has different criteria for acceptance and burial of radioactive gases in Federally approved containers. The Richland, Washington site is licensed to accept pressurized containers (up to 1.5 atmospheres absolute) of gases containing not more than 100 curies per container. The containers must also be buried individually and located at least 10 feet from neigboring containers. Given the site restrictions for burial of radoactive gases at Richland, the inventory of Kr-85 from TMI would require approximately an acre and a half of burial space.

The site in Beatty, Nevada is licensed to accept gas containers that are pressurized up to one atmosphere (absolute) and limited to 1000 curies or less. Gas containers containing from 100 to 1000 curies must be surrounded by at least 6 inches of concrete on all sides.

It should be noted that transportation of radioactive gases for disposal in commercial shallow land burial sites has not been a common practice in the U.S.

Given the burial site limitations for container pressure and curie content, and the required use of DOT and NRC approved shipping containers, the number of required containers for transporting 57,000 Ci of Kr-85 is potentially high. Under ideal conditions, a minimum of 57 and 570 containers would be required for acceptance at Beatty and Richland, respectively.

The environmental impact resulting from the burial of 57,000 Ci of Kr-85 would essentially be the population exposure incurred by the workers who would be required to package the gas at TMI, handle the gas shipping containers, transport the gas to a low level waste burial site and handle the gas containers at the burial site. The packaging and transportation of the Kr-85 gas would be conducted in accordance with appropriate DOT and NRC regulations. The estimated exposure resulting from these operations would range from 8 to 24 person-rems. The corresponding population exposure to members of the general public is negligible by comparison because of limited contact of the waste containers to the general public during transportation. In addition, the staff assumed that the population dose due to subsequent release (from corrosion of the containers in the ground) of the total inventory of Kr-85 gas is also negligible. The assumption is based on the minimal environmental dose impact of a release of 57,000 curies of Kr-85 (see Section 6.2) and low population density in the vicinity of the burial site.

The alternative to offsite burial is transportation to a remote location for controlled release to the environment. This alternative presupposes that a suitable facility would be constructed to effect a controlled release at the remote site. This alternative also assumes that there will be a negligible population dose to the public following release for the reasons elaborated above. Because the same basic operations (i.e., packaging, handling at TMI, transportation to a remote location, and handling at the remote site) and limitations (i.e., DOT and NRC packaging and transportation regulations) on this alternative apply to the operations for the burial alternative, the expected population dose is the same, namely, 8 to 24 person-rem. Although burial or release of the radioactive krypton of a remote site could be accomplished, the NRC staff believes this probably would not be acceptable to local officials and residents.

6.9.2 Summary

The environmental dose impacts resulting from the operations associated with transportation and offsite disposal would be in addition to the exposures incurred during the decontamination (i.e., during process operation) of the reactor building atmosphere but would not include the exposure incurred for the surveillance required during extended storage.

Although the environmental dose impact resulting from transportation and offsite disposal of the packaged Kr-85 is negligible, the NRC staff does not recommend this course of action for the following reasons. This course would presuppose the selection of a reactor building atmosphere decontamination alternative which would result in a delay of the entire TMI cleanup effort. Purging, as a method of decontamination, could be accomplished quickly with negligible public health consequences (see Section 7.0).

7. Health Effects

7.1 Physical

7.1.1 Summary and Conclusions

The NRC staff has determined that there would be negligible physical public health risks associated with the use of any alternative evaluated in this assessment, except the "no action" alternative. For the staff's proposed purging alternative in particular, this determination has been supported by others, including the U.S. Environmental Protection Agency, the U.S. Department of Health, Education, and Welfare and two groups of independent scientists reporting to the Governor of Pennsylvania. The Union of Concerned Scientists reported that, based on "current evidence of effects of whole body radiation on human populations, ...no health effects would be anticipated as a result of the 'ground release' venting" (Ref. 3). The National Council on Radiation Protection and Measurements (NCRP) in their report to the Governor, noted that "exposures likely to be received as a result of venting are no valid bases for concern with respect to health effects" (Ref. 23). In the NRC staff's judgment, there is, then, no physical public health basis for eliminating the purge alternative. Additionally it should be noted that, based on the relatively greater radiosensitivity of humans, there would be no adverse impact on plants or animals following purging.

7.1.2 Discussion

The NRC dose model for Kr-85 and other noble gases released at the time of the accident is based on present day state-of-the-art dosimetric models. Noble gases have no significant food pathway involvement or modes of exposure other than from immersion in a cloud of the gas. The NRC Kr-85 dose model is in good agreement with estimates provided by other groups. The National Council on Radiation Protection and Measurements provides a consensus of the risks of Kr-85 exposure in Krypton-85 in the Atmosphere--Accumulation, Biological Significance, and Control Technology (hereafter NCRP Report 44) (Ref. 24). Much of the basic information about Kr-85 in this section is derived from NCRP Report 44.

Krypton-85 is a radioactive isotope produced by the fission of several heavy isotopes, such as uranium-235, uranium-238, and plutonium-239. Most of the Kr-85 in the TMI-2 reactor building resulted from the fission of uranium-235 prior to the accident. Krypton is one element in the series of noble gases that include, in order of increasing atomic mass, helium, neon, argon, krypton, xenon, and radon. These gases are colorless, tasteless, and do not undergo chemical reactions with other molecules in living tissue. Krypton-85 has a 10.7-year radiological half-life and emits beta particles by two different decays. Beta emission is not followed by emission of a gamma ray for 99.6% of this decay process.

People are continuously exposed to Kr-85 which is normally contained in the world's atmosphere. 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. In the TMI area, for example, the U.S. Environmental Protection Agency has measured normal background concentrations to be about 30 pCi/m^3. This concentration results in annual Kr-85 background skin and total-body doses of about 0.00004 and 0.0000005 mrem respectively to all members of the public. This compares to an average annual total-body background dose (from sources other than medical) of about 100 mrem in the U.S. Medical and dental exposures normally account for another 100 mrem per year to individuals in this country.

Krypton-85 has low blood solubility and high lipid (fat) solubility, but diffuses rapidly in tissue to reach concentrations proportional to those in the surrounding air, a condition referred to as an equilibrium concentration. NCRP estimates that the equilibrium concentration of Kr-85 in body tissues (pCi/g) relative to the surrounding air (pCi/cm^3) is as follows: (1) separable fatty tissue, such as breasts, thighs, waistlines and around some body organs-41% of the concentration in air, (2) skeleton-13% of the concentration in air, (3) soft tissues (s ch as organs, muscles, brain, etc.), -8.3% of the concentration in air. Considering the dose from beta pa les and gamma rays (plus their resulting radiations, such as bremstrahlung*) both from around and inside a person, the skin is the organ that receives the highest numerical dose, followed by lung and bone tissue. However, as noted in NCRP Report 44, the skin is one of the least susceptible tissues to radiogenic cancer. Furthermore, while any cancer is potentially fatal, most skin cancers lend themselves to successful treatment.

The 1979 draft report of the Committee on the Biological Effects of Ionizing Radiation (National Academy of Science) provides a tentative estimate of risk of radiogenic skin cancer (Ref. 25). That model would indicate that the risk of inducing a fatal radiogenic skin cancer is less than 1% of the risk of death from other cancers resulting from total-body irradiation (per unit of dose). As a result, the NRC staff concludes that the total-body dose is critical for determination of cancer mortality risk for estimating genetic risk for both sexes. This will be discussed in more detail later in this section.

The NRC health effects model was developed in 1975 for the Reactor Safety Study by a 13-member advisory group, (three of whose members were also members of the 1972 National Academy of Sciences Committee on the Biological Effects of Ionizing Radiation (BEIR) (Ref. 26). The advisory group included six physicians, one veterinarian, and six life scientists. Two members were from the University of Pittsburgh School of Public Health.

The NRC health effects model is shown in Figure 7.1 in graphic form. This model, which uses observed estimates from the 1972 NAS/BEIR Report (Ref. 27), assumes that, following a radiation dose, there is a latent period during which no cancers occur. The latent peric is variable, and is assumed to be dependent only on the specific type of cancer.** Following the latent period there will a period in which cancers will be observed (plateau).

Using the total-body dose estimates for the alternatives shown in Table 1.1 and the NRC cancer mortality risk estimate of 135 deaths per million person-rem, the potential cancer deaths were calculated. The total potential cancer mortality to both the 50-mile population surrounding TMI-2 and to plant workers is estimated to range from a minimum of 0.0003 (purge option) to a maximum of 0.034 (cryogenic option).*** Almost all of that risk would be borne by workers exposed at the plant (purge = 0.0002, cryogenic = 0.034). The cancer mortality risk among the general population within 50 miles resulting from the purge option would be about 0.0001.

The maximum potential lifetime-individual risk of cancer mortality would accrue to a fetus that received the maximum estimated dose of 0.2 mrem. Using 300 deaths per million person-rems from Table 7.1, the excess cancer-mortality risk for this scenario would be six chances in 100,000,000 (0.00000006) compared to a current normal lifetime expectancy of one chance in five (0.2) from all types of cancers. Risks for all other age groups would be even lower than this extremely small value.

Using the total body dose estimates for the options shown in Table 1.1, and the NRC genetic effect risk estimate of 260 cases per million person-rem the potential genetic effects per generation were calculated. The total

*A type of X-ray.

**Animal studies indicate that the latent period generally increases with decreasing dose.

***EPA, in an April 11, 1980 letter to NRC, (Ref. 28) independently estimated 0.00022 and 0.057, respectively. These values represent close agreement with NRC estimates.

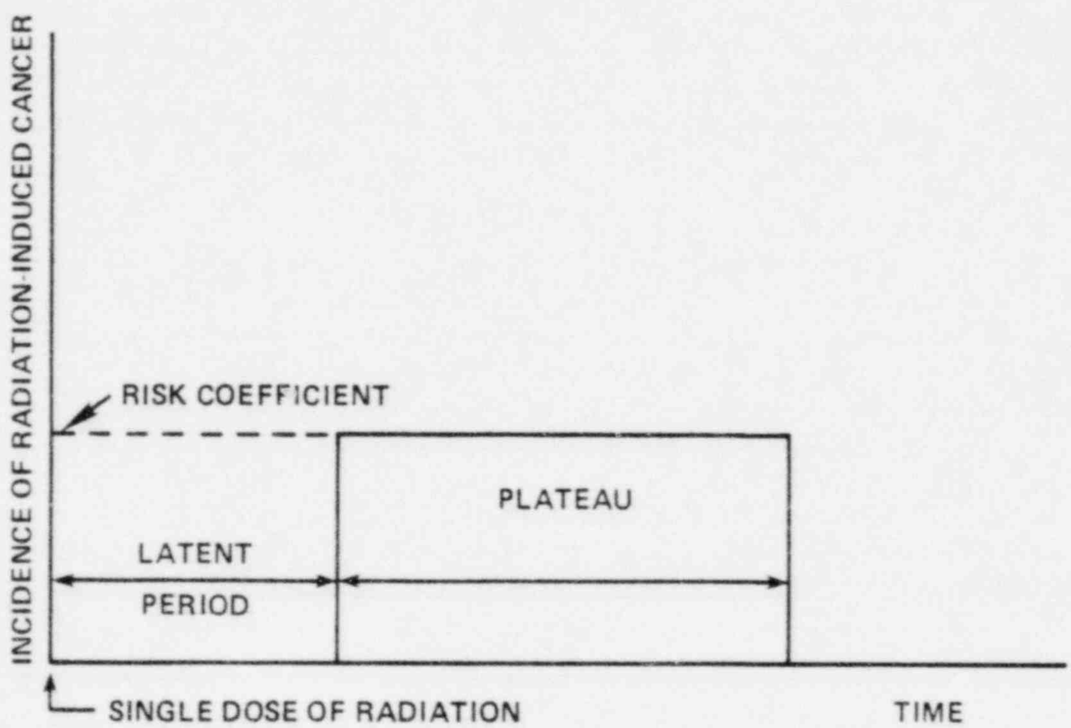


Figure 7.1 Basic Model for Latent Cancer Fatalities

potential for genetic effects in plant workers and the 50-mile population surrounding TMI-2 is estimated to range from a minimum of 0.0005 (purge option) to a maximum of 0.066 (cryogenic option). Almost all the risk would be borne by future descendants of workers at the plant (purge = 0.0003, cryogenic = 0.066). The maximum genetic risk to future descendants of any offsite member of the public would be five chances in 100,000,000 (0.00000005) compared to the current expectation of a normally occurring genetic effect at a rate between one and five chances in 100 (.01 to .05).

Recent cancer statistics indicate that more than 14 persons per 10,000 persons will contract skin cancer each year (calculated from Ref. 29). Thus, the typical risk of occurrence per lifetime is about 11%. Most of these cancers occur on the face, neck, arms, and hands due to exposure to the ultraviolet (UV) rays from the sun.

Since most skin cancers are not fatal, most are unreported in cancer registries. Estimates indicate more than 300,000 new cases of skin cancer occurred in the U.S. (population of 220 million) in 1979 (Ref. 29). However, of those cases reported, there were 5,900 deaths. Of those that died, 4,300 (out of 13,600 cases) were from melanomas,* and 1,600 (out of more than 300,000) were from other types of skin cancer. Therefore, the mortality rates were about 30% for melanomas and less than 0.5% for non-melanomas. The overall lifetime mortality risk of all types of skin cancer is currently less than 2 chances per 1,000 persons (that is, about 1.5% of the total risk of cancer mortality).

The 1979 draft BEIR report indicates on the order of one <u>case</u> of skin cancer will develop per year per million person-rem of low LET radiation (such as emitted by Kr-85) (Ref. 25). Although no studies have indicated a definite increase in melanomas as a result of radiation exposure, it was <u>assumed</u> for this assessment that the lifetime risk of mortality (not incidence) from radiogenic skin cancers is the same as for naturally occurring spontaneous skin cancers. That assumption implies that the lifetime mortality risk is on the order of one death per million person-rem (skin).

Based on this assumption, the lifetime cancer mortality risk from a total body dose is at least 135 times greater than a comparable skin dose.** The beta dose to the exposed skin from Kr-85 is about 80 times greater than the total body gamma dose for unprotected members of the public. This implies that the cancer mortality risk from Kr-85 skin doses to the public would be on the order of 60% of the cancer mortality risk from the Kr-85 total body dose.

Therefore a skin dose of 11 mrem to an individual (purge option) would be predicted to cause less than one (about 0.000006) additional skin cancer mortality among the 50-mile population of 2.2 million people. This compares with 4,000 expected deaths from skin cancer from other causes (primarily sunlight), and over 400,000 total expected cancer deaths in the area regardless of whether the Kr-85 is released or not.

Using the estimates of average life-shortening in Table 7.1, and the dose estimates in Table 1.1, it is possible to estimate the average loss-of-life expectancy associated with latent cancer mortality. The maximum life-shortening would result from irradiation of a fetus in the mother's womb. Using 7.2 days per rem, the maximum dose of 0.2 mrem would result in a statistically average risk of 2.1 minutes. Risks to all other age groups would be even less.

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*Melanomas are a rare but dangerous skin cancer.

**$\frac{135 \text{ cancer deaths}/10^6 \text{ person-rem (total body)}}{\leq 1 \text{ cancer deaths}/10^6 \text{ person-rem (skin)}} \leq 135$

Table 7.1 Summary of Age Specific Cancer Mortality Risk Estimators and Associated Life-Shortening

Age Group	Potential Cancer Mortality per 10^6 Person-Rem*		Average Life-Shortening per Person-Rem*	
		Totals	Hours	Total Days
In-Utero	150 Leukemias 150 All others	300	87	7.2
0-0.99 years	50 Leukemias 43 All others	93	25	1.5
1-10 years	50 Leukemias 55 All others	150	24	1.5
11-20 years	25 Leukemias 171 All others	196	10 12	2.0
20-70 years	23 Leukemias 108 All others	131	5 10	0.63
All ages	28 Leukemias 107 All others	135	10 18	1.2

*For a population composed only of that age group.

A summary of other common competing risks of mortality comparable to the maximum total-body dose (purge option) is shown in Table 7.2.

Table 7.2. Summary of Lifetime Risks of Mortality Numerically Equivalent to 0.2 mrem

Type of Activity	Equivalent Mortality Risk*	Causes of Deaths
Cigarette Smoking	Inhaling of few puffs	lung cancer and cardiovascular diseases
Drinking	A few sips of wine	cirrhosis of the liver
Automobile driving	three miles	accidental death
Commercial flying	14 miles	accidental death
Canoeing	20 seconds	drowning
Being a man aged 60	one minute	all causes of death at age 60

*Sir Edward Pochin, "The Acceptance of Risk," (Ref. 30).

The staff has compared the dose conversion factors for the noble gases released during the TMI-2 accident with that for Kr-85. It can be shown that it would require the release of approximately 500 million Curies of Kr-85 under the same exposure conditions that existed during the accident to result in population doses comparable to those received from the 10 million curies of xenon and krypton radioisotopes actually released during the accident. Stated another way, the release of 57,000 Curies of Kr-85 under accident exposure conditions would have resulted in only about 0.01% of the population dose which was estimated to have resulted from the accident.

It should be noted that even the relatively large amounts of noble gases (including Kr-85) released during the accident were determined to present little risk to the public by the Kemeney Commission (Ref. 31), Rogovin Report (Ref. 32), and NRC staff (Ref. 17).

Comparison with Other Radiological Risks

A summary of other common competing risks of mortality comparable to the maximum total-body dose (purge option) is shown in Ta' ,e 7.3.

Table 7.3. Summary of Latent Radiogenic Cancer Risks Comparable to 0.2 mrem

Type of Exposure	Equivalent Radiological Risk	Source of Dose
Commercial Subsonic jet travel	29 minute flight at 30,000 ft.	cosmic rays (Ref. 33)
Commercial supersonic jet travel	18 minute flight at 60,000 ft.	cosmic rays (Ref. 33)
Living in Denver, Colorado (as opposed to Middletown)	one day	cosmic ray and terrestrial radiation (Ref. 34)
Moving to a location about 20' higher in elevation than Middletown (same type of home)	one year	cosmic rays (Ref. 34)
Sleeping with another person	about eight months at eight hours/day	naturally occurring K-40 gamma rays (Ref. 35)
Living at the site boundary of a coal-fired plant	about two weeks	natural radioactivity emitted by coal combustion (Ref. 36)
Living in a tight, energy-efficient house	about one night	increased levels of Rn-222*

Assumes (a) one extra 0.001 μCi of Rn-222 per m^3 of room air (actual measurements have shown up to 0.03 μCi of Rn-222/m^3)* and 50% equilibrium for radon progeny, (b) 2×4^{-4} lung-cancer deaths per working-level month (WLM), and (b) being at home 100 hours per week (or approximately 15 hours per day). Therefore,

$$\left(\frac{2 \times 20^{-4} \text{ lung cancer deaths}}{\text{WLM}}\right) \times \left(\frac{0.005 \text{ WL @ 50 percent equil}}{0.001\ \mu\text{Ci/m}^3}\right) \times \left(\frac{100 \text{ hrs/wk}}{40 \text{ hrs/wk}}\right)^{**} \times$$

$$\left(\frac{12 \text{ months}}{\text{yr}}\right) = \frac{30 \text{ deaths}}{\text{million people}}$$

or: 3 chances in 100,000

compare with (0.0002 rem) x (1.35×10^{-4} cancer deaths/(rem)

= 3 chances in 100,000,000

i.e., about 1,000 times greater risk for an energy efficient house

$$\sim \left(\frac{365 \text{ days}}{1000}\right) \times \left(\frac{24 \text{ hrs}}{\text{day}}\right) \sim 8.8 \text{ hrs (a good night's sleep)}$$

*Hallowel, et al., invited paper, 1979 Meeting of the American Nuclear Society, San Francisco, CA.

**Correction for differences in exposure periods at home compared with uranium miners.

Based on the cancer statistics just discussed, about 11 out of every 100 persons will develop a skin cancer during their lifetimes (Ref. 24). It is assumed that most of the current risk is due to exposure of the skin to ultraviolet rays from the sun. Since the current risk of skin melanomas among black persons is only about 18% that of white persons, it was assumed the difference is largely due to greater protection of the germinal layer of skin from UV by melanin pigments in the epidermis of black people. If it is conservatively assumed that the difference is due only to UV irradiation, then about 80% of all skin cancers in the U.S. would be due to exposure to the sun (i.e., about 9 cases per hundred persons).

Comparing these figures with the 1979 draft BEIR estimate of about one case per year per million person-rem (Ref. 25) indicates that background radiation accounts for less than 1% of the expected skin cancers.* This is further evidence that the skin is relatively insensitive to ionizing radiation.

Some people (for example, farmers, commercial fisherman) spend as much as a third of their lives exposed to the direct rays of the sun (primarily head, neck, arms, and hands). Others (e.g., miners, office workers, etc.) may spend less than one-tenth of each adult work day in the sun. It was assumed here that the average person spends about 3 hours per day (including weekends, childhood and retirement years) in the sun. The average risk of UV induced skin cancer is therefore:

$$\frac{0.09 \text{ skin cancers}}{(3 \text{ hrs/day})(365 \text{ days/yr})(75 \text{ yrs/person})}, \text{ or } 1.1 \times 10^{-6} \text{ skin cancers/hour of sun.}$$

Using the 1979 draft BEIR estimate of 10^{-6} cases of radiogenic skin cancer per year per person-rem yields on estimated equivalence of 0.045 hours of exposure to sunlight and one millirem of skin dose (Ref. 25).**

Using the maximum individual skin dose estimated by NRC (11 mrem), the added average risk of skin cancer would be equivalent to spending 30 minutes in the sun. The average individual in the population would have an added risk of skin cancer equal to about a half-second of exposure to the sun's rays.

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*Expected: $0.11 \times 2.2 \times 10^8 = 24$ million cases of skin cancer. From 0.1 rem/yr of background radiation:

$$\left(\frac{\sim 75 \text{ years}}{\text{lifetime}}\right)\left(\frac{0.1 \text{ rem}}{\text{year}}\right)(2.2 \times 10^8 \text{ persons})(\sim 50 \text{ years at risk})\left(\frac{1 \times 10^6 \text{ skin/cancers/yr}}{\text{person-rem}}\right)$$

$$= 8 \times 10^4 \text{ skin cancers or, } \frac{8 \times 10^4 \times 100\%}{2 \times 10^7} \leq 0.4\% \text{ of total expected}$$

$$^{**}\left(\frac{1 \times 10^{-6} \text{ skin cancers/yr per person-rem}}{1.1 \times 10^{-6} \text{ skin cancers/hour of sun}}\right)(50 \text{ years at risk}) = \frac{45 \text{ hours}}{\text{person-rem}}$$

7.2 Psychological Stress

7.2.1 Conclusion

The staff concludes that the psychological stress resulting from atmospheric purging will be less severe than from any of the other decontamination alternatives. Purging the reactor building is the quickest of the decontamination alternatives and will, therefore, result in stress of shorter duration relative to the other alternatives. Such alternatives would use considerably more complex equipment and processes and would thereby prolong the uncertainties and associated stress over the possibility of accidental releases. In addition, removing Kr-85 from the reactor building may be perceived as a crucial first step in progress toward overall decontamination of TMI-2 and elimination of the potential for future disruption from that unit.

The staff acknowledges that the purging recommendation may be unpopular to a segment of the local population and perceived as further evidence of NRC insensitivity to their apprehensions. Nonetheless, the staff believes that, given the absence of radiological risk from the purging option, in the long run, prompt decontamination of the reactor building atmosphere will substantially alleviate psychological stress due to a concern over unplanned radiological releases from the facility and doubts about the ability and decisiveness of the NRC to take affirmative measures.

7.2.2 Discussion

A number of studies reported psychological distress as widespread in the population around Three Mile Island at the time of the accident (Refs. 31, 37-39). Moreover, some level of psychological distress continues to be associated with various issues surrounding the current and future status of the facility (Refs. 38, 39). In particular, anxiety is high among some members of the population at the prospect of krypton-85 releases to the environment from the Unit 2 reactor building (Ref. 31). Recognizing this fact, the staff has explored the possible different levels and characteristics of psychological stress associated with each of the decontamination alternatives. In reaching conclusions on the relative psychological impacts among the alternatives, the staff considered several sources, including studies of psychological stress and psychological sequedea (or after effect) of disasters. Of particular relevance were studies, by experts on psychological stress (Refs. 31, 37-41), that specifically addressed conditions in the Three Mile Island area and an evaluation of public comments. The Human Design Group, assisted the staff's evaluation. The Human Design Group's principal members are affiliated with the Department of Medical Psychology, Uniformed Service University of the Health Services. Based on consultations with psychologists the staff concludes that the purging alternative has less potential for creating long-term psychological stress than those alternatives which take longer to implement.

Psychological stress is a complex set of mental, behavioral and physiological phenomena, a response pattern resulting from a person's appraisal of an event or situation that threatens some kind of danger, harm, or loss. These patterns include increased physical and psychological arousal, and a search for alternatives to cope with or reduce danger or loss. If a perceived threat is not controlled or reduced, a person affected may suffer psychological as well as physical strain and their consequences. Stress may be induced by a wide variety of situations or events. The level of stress is generally associated with a person's perception of the severity of loss or harm. While most persons have the capacity to recover quite well from acute stress caused by a specific event, a small percentage of a population may experience lasting physical and/or emotional effects from the same event. Such chronic stress, however, is usually related to events which cause stress for long periods. While chronic consequenses of short-term events that cause stress are still an open question, the long and short-term symptoms are similar: emotional tension, cognitive impairment, and somatic complaints.

The conclusions on the psychological stress associated with atmospheric decontamination of the TMI-2 reactor building are, in part, based on three valuable studies that have received wide distribution. They are Dohrenwend's technical report (Ref. 37) for the Kemeny Commission, Houts' study (Ref. 38) for the Pennsylvania

Department of Health, and Flynn's preliminary report (Ref. 39) on the TMI telephone survey of residents around TMI for the NRC. Each of these studies attempts to answer in part the question, "What are the mental health consequences of the accident?" Each examined different indicators of psychological stress, some of which are reports by individuals on their physical or mental well-being. These reports, nevertheless, agree that there was an increase of psychological stress initially following the accident that had diminished by mid-summer, 1979. They felt that this drop indicated that stress linked with the accident was acute or event specific. Houts (Ref. 38) and others (Refs. 37-39), however, find several indicators of stress that remain high even aft. the accident. The continuing stress seems related to two issues: future decontamination plans for TMI-2, and a distrust of those responsible for these activites. These two interrelated issues represent a new source of stress that continues beyond the accident. The Kemeny Commission suggests that stress was induced and exacerbated by a lack of confidence in those currently in charge of TMI operations. These stresses are seen to be acute. In addition, the Commission[4] proposes that any increase in the incidence of long-term mental or physical health problems caused by the accident will be insignificant. The effects of stresses in the post-accident period are uncertain; however, several researchers (Refs. 40, 41) foresee no long-term stress-related health problems.

As a result of the above review, the staff suggests that current distrust of authority in a percentage of the population will be an important factor in the community's evaluation of any decontamination plan (Refs. 37-39). Such distrust can heighten a person's or a community's perception of potential danger and their feelings of lack of control, as was found in several studies (Refs. 38, 39). These feelings may cause some TMI residents to resist any agency-sponsored action. The level and duration of stress is determined in part by how long the source of the stress is present and by how people perceive their ability to cope with it. Perceived feelings of lack of control found in the TMI community are enhanced by previous conflicting and inconsistent stances made by the major organizations involved during and after the accident (Ref. 31).

In addition to stress related to distrust of authority, there is the issue of duration of stress and related stressors. Some stress will exist in the TMI area as long as decontamination is delayed and agencies are seen by some to lack credibility and are perceived as insensitive to the area's welfare. Acute stress for many residents could be elevated by the purging, but should diminish thereafter. Thus, three sources of stress seem pertinent to TMI-2 decontamination: (1) the duration of reactor building atmosphere decontamination operations; (2) the immediate fears purging arouses; and (3) distrust of authorities responsible for decontamination activities.

8.0 Radiological Environmental Monitoring Program

8.1 Introduction

The radiological environmental monitoring around the TMI site and nearby communities during decontamination of the reactor building atmosphere would be performed by (1) the U.S. Environmental Protection Agency (EPA), (2) The Commonwealth of Pennsylvania, (3) the U.S. Department of Energy, (4) the Nuclear Regulatory Commission, and (5) Metropolitan Edison Company (the licensee). Each program is summarized in the following subparagraphs; a more complete description is given in the EPA report, "Long-Term Environmental Radiation Surveillance Plan for Three Mile Island," March 17, 1980.

8.2 U. S. Environmental Protection Agency (EPA) Radiological Monitoring Program

EPA has been designated by the Executive Office of the President as the lead Federal Agency for conducting a comprehensive long-term environmental radiation surveillance program as a follow up to the accident at TMI-2. EPA has recently incorporated a separate section in their surveillance plan detailing the monitoring program to be implemented should the NRC staff proposal to purge the reactor building atmosphere be approved. EPA operates a network of 18 continuous air-monitoring stations at radial distances ranging from 0.5 mile to 7 miles from TMI. Seven miles was established as the point well beyond that which EPA expects to detect any emissions from TMI-2. Each station includes an air sampler, a gamma rate recorder, and three TLDs. A list of sampling locations is shown in Table 8.1. These stations constitute EPA's baseline, long-term monitoring program. The air sampler units sample at approximately 2 cfm and the samples are collected from each station and analyzed typically three times per week. All samples are analyzed by gamma spectroscopy at EPA's Harrisburg Laboratory using a Ge(Li) detector with a lower limit of detection for cesium-137 or iodine-131 of approximately 25 pCi (0.15 pCi/m3 for a 48-hour sample).

Each monitoring station is equipped with a gamma rate recorder for measuring and recording external exposure. Recorder charts are read on the same schedule used for air sample collection and the charts are removed weekly for review and storage at EPA's laboratory in Las Vegas, Nevada.

Thermoluminescent dosimeters have been placed at each monitoring station and at 0.25 mile intervals along roads immediately parallel to the Susquehanna River near TMI out to a distance of about 2.5 miles from the reactor. TLDs have also been placed on the islands located 0.5 miles to 1.5 miles west of the reactor site (Shelley, Hill, Henry, Kohr and Beech Islands). These dosimeters are read quarterly.

In addition to the above, a weekly compressed gas sample is taken at the Observation Center and sent to EPA Las Vegas for a determination of krypton and xenon.

The EPA's base long-term program discussed above will continue and will be augmented in the following manner if purging of krypton is approved.

A monitoring program consisting of survey meter and ion chamber measurements, collection of compressed air samples for Kr-85 analysis and intensified collection of samples from routine air monitoring stations will be implemented.

A. Mobile Monitoring - survey meter and ion-chamber

A minimum of three mobile radiation monitoring personnel equipped with survey instruments and one low range pressurized ion-chamber will be positioned in the predicted downwind trajectory during purging. Monitoring personnel will be drawn from other Federal agencies as well as from the EPA in order to provide 24 hour coverage. In additi.n to making radiation measurements throughout the day, personnel will be prepared to collect compressed air samples based on those measurements.

B. Krypton-85 Sampling

Four compressed air sampling units will be positioned at fixed locations for the collection of weekly samples. The units will be placed at Middletown, the Observation Center, Bainbridge and Goldsboro in order to provide representative coverage with emphasis in the predominant wind directions. Sampling will be conducted for one to two weeks prior to purging to provide background data for the TMI area. Samples routinely collected in Nevada will provide an indication of wor'dwide ambient Kr-85 levels for comparative purposes. In addition three compressed air sampling units will be deployed with the mobile monitors. A minimum of one sample will be collected each day (at the predicted offsite location of maximum plume concentration). Additional samples will be collected, when necessary, based upon survey meter and ion-chamber data. All samples will be analyzed at the EPA laboratory facilitie in Harrisburg.

C. Tritium Monitoring

One molecular sieve sampler will be operated at the Observation Center for collection of atmospheric moisture for tritium analysis. Analyses will be performed at the EPA laboratory facility in Harrisburg.

D. Routine Air Monitoring Network

In order to verify that no radionuclides other than Kr-85 are released to the environment during purging, samples from the established network of eighteen operating stations will continue to be collected. Samples in the downwind sector will be collected every day, rather than the three times per week under normal conditions. In addition at least one sample from "control" stations in each quadrant not in the downwind trajectory will be collected and analyzed on a daily basis.

EPA reports all results of their monitoring measurements from their baseline program three times each week to the public and news media. If Krypton purging is approved, EPA will make daily reports to the public and news media starting approximately two weeks before intiation of purging, and continuing until purging is completed.

8.3 Commonwealth of Pennsylvania Radiological Monitoring Program

The Department of Environmental Resources of the Commonwealth of Pennsylvania operates three continuous air sampling stations; one at the Evangelical Press Building in Harrisburg, one at the TMI Observation Building, and one in Goldsboro near the boat dock. Each air sampling station consists of a particulate filter followed by a charcoal cartridge. The filters and cartridges are changed weekly; the particulate air samples are gamma scanned and beta counted for reactor-related radionuclides. The particulate air samples are composited quarterly and analyzed for Sr-89 and Sr-90. The charcoal samples are gamma scanned for reactor-related radionuclides. They do not, however, have the capability to sample or analyze for Kr-85.

8.4 U.S. Department of Energy

8.4.1 Community Monitoring Program

The Department of Energy and Commonwealth of Pennsylvania are sponsoring a Community Radiation Monitoring Program. This program has as its purpose to: (a) provide independent verification of radiation levels in the TMI area by trained local community people, and (b) to increase public understanding of radiation and its effects. The approach to achieve this purpose has involved the selection of individuals by local officials from the following 12 communities within approximately five miles around TMI.

East Manchester Twp.
Londonberry Twp.
York Haven
Lower Swatara Twp.
Conoy Twp.
Goldsboro
Fairview Twp.
Royalton
West Donegal Twp.
Middletown
Newberry Twp.
Elizabethtown

Approximately 50 individuals participated in training classes conducted by members of the Nuclear Engineering Department of the Pennsylvania State University. Approximately 15 training sessions were conducted involving classroom instructions, laboratory training, and actual radiation monitoring in the field. The teams utilized EPA gamma rate recording devices which are currently in place around TMI and will be supplemented by gamma/beta sensitive devices which are being furnished by DOE through EG&E Idaho, Inc. This training was structured to cover the following areas:

1. Classroom instruction

   ° Introduction to radioactivity
   ° Interaction of radiation with matter
   ° Methods of radiation detection
   ° Radiation counting variables
   ° Radiation protection units
   ° Health physics procedures
   ° Radiation interaction with biological systems
   ° Administrative procedures for Community Radiation Monitoring Program
   ° TMI-2 accident and cleanup
   ° Meteorological conditions

2. Laboratory instruction

   ° G. M. (Geiger Mueller) counting experiments
   ° Radiation counting statistics
   ° Monitoring equipment familiarization

- Argon-41 and Krypton-85 monitoring
- Supervised area monitoring with actual procedures and equipment

At the completion of the instruction phase, a final examination was given. This was followed by field monitoring training of approximately one week.

The training sessions provided basic information on radiation, its effects, detection techniques, and included hands-on experience with monitoring equipment in the field. Citizens were expected to demonstrate competence in both the theoretical and practical aspects of the course before actual monitoring efforts begin. Following the completion of training in the third week of April, team representatives in each of the 12 selected areas began data acquisition from the gamma and gamma/beta sensitive instruments on a routine basis. Detailed procedures were developed to consolidate the information being obtained into a central point of contact in the Commonwealth of Pennslyvania for dissemination to the press, local officials, and other interested parties on a routine basis. Maintenance and calibration procedures were also developed and are in place prior to the initiation of routine field monitoring. The Community Monitoring Program was initiated on May 21 and the results of measurements from this program are reported daily to the public.

8.4.2 DOE - Atmospheric Release Advisory Capacity

The Department of Energy will make available during the purging operations its Atmospheric Release Advisory Capacity (ARAC). This ARAC system will provide independent predictions of the dispersion patterns for the krypton release based on local meteorological data and National Weather Service reports. These predictions will use atmospheric dispersion models which have been verified during many years of field experience and tests in Government programs. The predicted dispersion patterns will be provided to the Environmental Protection Agency to serve as a basis for their positioning of ground level monitoring teams. These predictions will also be provided to the utility and the NRC, as an additional means of assuring that the purging operation is being adequately controlled.

8.5 U.S. Nuclear Regulatory Commission Radiological Monitoring Program

The Nuclear Regulatory Commission (NRC) would operate one air sampling station located in the middle of the reactor complex. The air samples would be changed weekly and analyzed by gamma spectrometry. The NRC would place two sets of TLDs at 59 locations as shown in Table 8.2. Both sets would be read on a monthly basis; however, flexibility exists to read one set at more frequent intervals should conditions warrant.

8.6 Licensee's Radiological Environmental Monitoring Program

The licensee normally utilizes 72 radiological environmental monitoring locations to monitor plant releases with two thermoluminescent dosimeters (TLDs) at each location. In addition to these required TLDs, four additional TLDs will be placed in each of these locations during controlled purge; two for periodic readouts (frequency depends upon purge duration and the influence of plume) and the remaining two for assessment of the integrated dose over the entire purge period. In anticipation of certain sectors coming under the influence of the plume for a greater duration of purge period, additional TLDs will be placed in selected areas.

In addition to the TLD monitoring, grab air samples will be obtained by an individual(s) dispatched via two-way communications to the projected plume touchdown area during the controlled purge. The air sampler will be placed and operated such that a grab sample will be obtained over a 15-20 minute period while immersed in the plume. Hourly update of plume direction and touch-down area, utilizing real time monitoring and an assessment program, will be obtained and disseminated to field sampling teams.

Table 8.1
Three Mile Island
EPA Long-Term Surveillance Stations
Air Samplers, Gamma Rate Recorders, TLDS

STATION	AZ	DISTANCE (Miles)	ASSOCIATED TOWN
3	325	3.5	Meade Heights, PA - Harrisburg International Airport
4	360	3.0	*Middletown, PA - Elwoods' Sunoco Station
5	040	2.6	Royaltown, PA - Londonderry Township Building
9	100	3.0	Newville, PA - Brooks Farm (Earl Ninsley Residence)
11	130	2.9	Falmouth, PA - Charles Brooks Residence
13	150	3.0	Falmouth, PA - Dick Libhard Residence
14	145	5.3	*Bainbridge, PA - Bainbridge Fire Company
16	180	7.0	*Manchester, PA - Manchester Fire Dept.
17	180	3.0	*York Haven, PA - York Haven Fire Station
20	205	2.5	Woodside, PA - Zane Resner Residence
21	250	4.0	*Newberrytown, PA - Exxon Kwick Service Station
23	265	2.9	Goldsboro, PA - Muellar Resident
31	270	1.5	*Goldsboro, PA - Dusty Miller Residence
34	305	2.7	Plainfield, PA - Polites Residence
35	068	3.5	Royaltown, PA - George Hershberger Residence
36	095	0.5	TMI Observation Center
37	025	0.7	North Gate, TMI
38	175	0.8	South Gate, TMI

*Sampling stations located in indicated town. Other sampling stations are located near indicated towns.

Table 8.2

DESCRIPTION OF NRC TLD LOCATIONS

E1 - Hwy. 441 on Laurel Road 1st telephone pole on right outside vendor TLD box. 90° 0.45 mi

NE1 - On telephone pole by George Beyer Market, Geyers Church Road off 441. 25° 0.8 mi

NE2 - On telephone pole at intersection of Hillsdale and next road on left from Geyers Church Road (closed road to gold church) by yellowish red house. 19° 1.9 mi

N1 - On chain link fence for power substation, Middletown SE corner. 358° 2.6 mi

NE3 - On telephone pole on Rt. 230 directly across from Shady Lane Motel. 15° 3.05 mi

NE4 - On telephone pole on Rt. 743 just north of Texaco station, just north of Turnpike underpass. 55° 6.5 mi

N2 - On telephone pole on Middletown Road N of Rt. 283, directly across the street from childrens care center.

N3 - On sign pole on Middletown Road at intersection to Rt. 322 E. Signpole says 322 West. 0° 7.0 mi

N4 - On telephone pole on Hoe Road, just N. of intersection of Union Deposit Road. 2nd pole on left. 0° 9.0 mi

N5 - On telephone pole on Rt. 39 at intersection of Rt. 22 (Allentown Rd.) 0° 13 mi

NW5 - Environmental Station (Met Ed) at West Fairview, rear to Annex Building Fairview Fire Department, adjacent to tracks. 305° 15 mi

NW4 - On telephone pole on Meadowbrook just off Bridge Street, one block on N. side from Bridge Street. 300° 8.6 mi

NW3 - On telephone pole on Old York Road. 1st pole over turnpike overpass, west side. 295° 7.4 mi

NW2 - On telephone pole on Marsh Road by Culvert under RR tracks off Old York Road. 300° 5.9 mi

NW1 - On telephone pole directly in front of church at intersection of Rt. 262 E and Rt. 392 W (Valley Road and Yocumtown Road). 305° 2.6 mi

W1 - On "No Parking Any Time" sign within 18' of water at old boat ramp at Goldsboro. 264° 1.25 mi

W2 - On constant monitor inside chain link fence to Monitoring Station, Goldsboro on Rt. 262. By stream. 252° 1.3 mi

SW1 - On telephone pole approximately 25' from tracks in turn around full of flattened beer cans. Across from 2 small trailers (green and blue) in clearing (N end). 200° 2.1 mi

W3 - On telephone pole on Pines Road at intersection of 974 Red Mill Road. near Newberry. 264° 2.9 mi.

W5 - On telephone pole at intersection of Rt. 382 and Rt. 177 NW corner Lewisburg. 259° 7.3 mi.

W4 - On telephone pole on Rt. 392 (Pathshill Road) just beyond Ridge Road on S. side. Beyond sharp bend. 266° 5.9 mi

Table 8.2 (Continued)

SW2 - On telephone pole at intersection of 382 E and 295. Diagonally across from Texaco station, York Haven Road and Reeders Hill Rd. Pleasant Grove. 203° 2.5 mi

S-1 - On telephone pole at intersection of Rt. 181 and 382. Across street from York Haven Office. In front of Catholic church, York Haven. 168° 3.15 mi

S-2 - On telephone pole at intersection of Meeting House Road and N. George Street (Rt. 181 S), Manchester. 175° 5.1 mi

S-3 - On telephone pole on Rt. 238 at intersection to Rt. 181 S. By old brick and cement block building, Emigsville. 180° 9.1 mi

SW3 - On telephone pole at intersection of Lewisberry Road and Butter Road. By small frame house near Anderson town. 210° 8.1 mi

SW4 - On telephone pole at intersection of Butter Road and Bull Road 215° 10.1 mi

S-4 - York substation, sampling enclosure. 180° 12 mi

SE5 - On telephone pole at intersection of 441 N and Vinogary Ferry Road across entrance to Cargill Truck entrance.

SE4 - On pole at intersection of 441 N and 241 N. Pole next to fruit stand. 141° 4.6 mi

SE3 - On chain link fence on right side by Collins Substation sign at intersection of 441 and Falmouth Road. 160° 2.25 mi

SE2 - On telephone pole at intersection of 441 N and Turnpike Road. 162° 1.85 mi

SE1 - On telephone pole across from Red Hill Farm fruit stand 441 N, 1 mile from 3 Mile Island. 150° 1 mi

E2 - On telephone pole at Hillsdale Road and Turnpike Road. 110° 2.7 mi

E3 - On telephone pole at Turnpike Road and Bossler Road. 101° 3.7 mi

E4 - On telephone pole at intersection of W Hight Street and Mosorie Road, Elizabethtown. 90° 7.0 mi

E5 - Meadow Lane, 1st house on south side of street. 86° 0.4 mi

N	- Rte 441	03°	1.8 mi
NE	- Under TMI high tension lines	44°	1.1 mi
ENE	- Rte. 230	64°	3.8 mi
SE	- Rte. 411	130°	0.5 mi
SSW	- Beech Island	203°	0.7 mi
SW	- Newberry Township	227°	1.8 mi
NNW	- Shelly Island	289°	0.3 mi

Table 8.2 (Continued)

WNW - Town of Plainfield	301°	1.3 mi
NW - Hill Island	316°	1.2 mi
NW - Highspire	326°	5 mi
NNW - Kohr Island	332°	0.5 mi

NRC - TLD SCHOOL LOCATIONS

N1a NORTHUMBERLAND SCHOOL
2.4 mi N

N1b MANSBERGER SCHOOL
2.7 mi NNW

N1c FEASER SCHOOL
3 mi N

N1d CAPITOL CAMPUS, PENN STATE U.
3.5 mi NW

N1e GRANDVIEW SCHOOL
3.5 mi NNW

N1f MIDDLETOWN HIGH SCHOOL
4 mi NNW

NE-3a TOWNSHIP SCHOOL
3.6 mi NE

W-3a NEWBERRY SCHOOL
4.4 mi W

S-1a YORK HAVEN-NEWBURG SCHOOL
3.3 mi S

SE-4a BAINBRIDGE SCHOOL
5.0 mi SE

9.0 Response to Comments

9.1 Introduction

The draft "Environmental Assessment for Decontamination of the Three Mile Island Unit 2 Reactor Building Atmosphere" (NUREG-0662) and two subsequent addenda were issued for public comment. The public comment period for these three documents ended May 16, 1980. At the close of the comment period approximately 800 responses had been received. Comments on the Environmental Assessment were received from various Federal, State, and local agencies and officials; from nongovernmental organizations, and from private individuals. All substantive comments received appear in Volume 2 of this Assessment. The comments received fell into one of three categories: (1) those supporting the purging alternative recommended by the NRC staff (approximately 195 responses), (2) those opposed to the purging alternative (approximately 500 responses), and (3) those who recommended decontamination alternatives other than those discussed in the Environmental Assessment or who otherwise commented on the assessment (approximately 105 responses). The third category also included all other comments on the five alternatives evaluated in the Environmental Assessment, as well as suggestions for additional methods for decontaminating the TMI-2 reactor-building atmosphere. Several of the responses included specific editorial comments. Where appropriate, these comments have been resolved by revision of appropriate sections of this final Environmental Assessment.

9.2 Comments Supporting the Recommended Purging Alternative

The NRC staff received approximately 195 responses supporting the purging alternative recommended in the Environmental Assessment.

9.2.1 President's Council on Environmental Quality (CEQ). CEQ stated that in their view the NRC staff's proposal to separate the decontamination of the reactor building atmosphere from the preparation of the Programmatic Environmental Impact Statement does not violate 40 CFR § 1506.1 (1979) (Limitations on actions during NEPA process) of the Council's regulations implementing the National Environmental Policy Act.

9.2.2 The U.S. Environmental Protection Agency (EPA). EPA stated that the most acceptable method for decontaminating the TMI-2 reactor building atmosphere is a controlled purge to the environment in as short a time as possible, when meteorological conditions most favor dispersion. EPA based its recommendation of this method on the very low environmental and public health impact that would result from the controlled release of the Kr-85 and stated that this method would eliminate the large occupational radiation exposure which could occur from use of the other decontamination alternatives. EPA also stated that their assessments of the offsite doses for the purging alternative were in general agreement with those calculated by the NRC staff and that the estimated health risk of releasing the Kr-85 was 0.0001 excess deaths to the 1,750,000 population within 80 kilometers (50 miles) of Three Mile Island.

9.2.3 U.S. Department of Health, Education and Welfare (HEW).

The HEW Bureau of Radiological Health commented that after reviewing the draft Environmental Assessment and its two addenda, it is their conclusion that the purging of the KR-85 in the TMI-2 reactor building to the atmosphere under controlled release is the prudent and proper course of action which provides minimal, if not zero, health impact. They further noted that although members of the public in the vicinity of TMI may call for alternatives that do not release the KR-85 to the environment, the occupational workers are also members of the public and the health impact (if any) best relates to the total population dose in person-rem (both occupational and general public). In this regard, they stated that it would be appropriate for the NRC to provide estimates of the total population dose (both offsite and occupational). The NRC staff has included these recommended dose estimates in this Final Environmental Assessment.

9.2.4 The U.S. Department of Energy (DOE).

DOE submitted two responses. The Assistant Secretary for Nuclear Energy stated that his staff had performed an independent review of the matter and had concluded that a controlled purge was indeed the preferred method for decontamination since it would result in less public radiation exposure than accrues from many other power plants, both nuclear and fossil. This response urged the Commission to act promptly on the matter, and in the event of NRC approval, offered the resources of DOE to assist in monitoring off-site conditions during the purging process to help guarantee that conditions remain within acceptable limits. (See Section 8.0). Their support for the purging alternative was reiterated by a DOE representative on April 25, 1980 during a Commission briefing on Selective Absorption Process as an Alternative in Dealing with Krypton in TMI-2 Containment.

The second DOE response, from the Assistant Secretary for Environment, stated that their review had identified several areas where they felt that additional information or clarification would enable a more complete assessment of the potential effects of the removal of krypton gas from the reactor building. The following comments on NUREG-0662 were offered for consideration:

> The accident analysis for each alternative, including the proposed action, should include estimates of the probability of occurrence of the worst case scenarios. This would permit a more complete evaluation of the potential for adverse health and safety impacts.
>
> A more precise estimate of the time necessary to implement the various alternatives should be provided because of the importance of this factor in the overall decision-making process. Estimates should be based on realistic projections of an accelerated construction/testing program for each alternative.
>
> The potential hazards associated with the storage of Kr-85 should be quantified to the extent possible in order to better reflect the seriousness of problems associated with the storage.
>
> A more detailed description of the monitoring program for the proposed action would be helpful. Advanced monitoring to calibrate and verify analytical methods for predicting the incremental dose at the site boundary should be discussed. The ability to promptly and accurately determine off-site concentrations also should be discussed in more detail.
>
> The description of DOE's radiological monitoring program (Section 8.0) does not represent an accurate summary of our current efforts. An updated version of this section is enclosed for your information.
>
> The nature and extent of the controversy surrounding the proposed venting should be presented. The basis for the technical questions being raised by various segments of the public and scientific community along with a critical evaluation of their concerns would provide a more meaningful assessment of the significance of the impacts of the proposal.

The recommendation to include estimates of the probability of occurrence of the worst case scenarios for the various postulated accidents was considered by the NRC staff. Since the health effects resulting from worst case accident scenarios for any of the alternatives are negligible, the probabilities of occurrence are irrelevant. Although these probabilities have not been quantified, they are considered low. As for the proposed actions to be taken in the event of a postulated accident, the NRC staff will require that appropriate emergency and contingency procedures be prepared and approved pursuant to the requirements of the facility Technical Specifications prior to the implementation of any decontamination alternative.

The estimated times to implement the various decontamination alternatives, including the use of accelerated construction/testing programs, have been reviewed.

The potential hazards associated with long-term storage of Kr-85 and the NRC staff's reason for recommending against long-term storage of Kr-85 are discussed in Section 6.8.

The description of the monitoring program to be used if the purging alternative is approved, has been revised and updated to reflect the current monitoring program. Section 8.0 contains a detailed discussion of the planned monitoring program, including an updated version of the DOE sponsored portion.

In its preparation of this final Environmental Assessment, the NRC staff has again evaluated, as recommended, the nature and extent of the controversy surrounding its recommendation to decontaminate the TMI-2 reactor building atmosphere by purging to the environment as presented in draft NUREG-0662. An evaluation of the public comments and responses to this proposal is contained in Section 9.0 of this final Environmental Assessment while Section 7.2 contains a discussion of the psychological aspects of the proposal.

9.2.5 Advisory Committee on Reactor Safeguards.

In a joint meeting between the NRC Commissioners and the Advisory Committee on Reactor Safeguards (ACRS) on April 11, 1980, several members of the ACRS recommended that the reactor building atmosphere should be decontaminated soon by controlled purging to the environment. Their reasons for this recommendation were that a controlled purge would permit less restricted access to the reactor building for equipment and instrument maintenance and repair which may be required in the near future, and that the health effects of a controlled purge would be very small.

9.2.6 Governor of Pennsylvania.

The Governor's comments were contained in a letter submitted to Chairman Ahearne after the Governor received an independent assessment of the proposed decontamination effort from the Union of Concerned Scientists (UCS). The Governor had requested this independent assessment and had been granted an extension of the public comment period to permit the completion of this independent assessment. In his letter to Chairman Ahearne, the Governor stated:

> This is to notify you of my views, on behalf of the Commonwealth of Pennsylvania, regarding the proposal now before you to remove radioactive krypton 85 from the Three Mle Island Unit 2 containment building by the process of venting it into the atmosphere.
>
> I have sought and received assessments from the broadest range of knowledgeable sources available regarding potential health effects of that proposal. These sources have included:
>
> *Members of your own staff, and especially Mr. Harold Denton, your director of nuclear reactor regulation.
>
> *The Union of Concerned Scientists (UCS), the nation's foremost critic, I believe, of existing nuclear power safety levels.
>
> *The National Council on Radiation Protection and Measurements (NCRP), an organization of distinguished scientists and physicians which has been instrumental in setting radiation health standards in this country for nearly 20 years.
>
> *Representatives of the electric utility and nuclear industries.
>
> *The U.S. Department of Health, Education, and Welfare.
>
> *The Governor's Commission on Three Mile Island.
>
> *The Pennsylvania Departments of Health and Public Welfare, the latter of which has jurisdiction in the area of mental health in our state.
>
> *The Pennsylvania Department of Environmental Resources (DER), including its Bureau of Radiation Protection.
>
> The assessments of these various groups and institutions are being forwarded to you under separate cover, and I respectfully request that you enter them into your official record on this matter.

> There is, I have found a broad-based consensus among these sources that the venting proposal now before you would have, in the words of the Concerned Scientists, "no direct radiation-induced health effects on the residents of this area." Similarly, the NCRP concludes: "the exposures likely to be received as a result of venting are not a valid basis for concern with respect to health effects."
>
> There is a consensus on the accuracy of the radiation dose rate calculations made by your staff, in conjunction with the utility, and there is a consensus that those dose rates are "insignificant."
>
> I should point out that the Union of Concerned Scientists feels that the psychological stress already experienced by many residents of this area since March 28, 1979 should seriously be considered in any decision you make with regard to the cleanup operation on Three Mile Island, and I agree with that. As you know, I previously instructed attorneys for the Commonwealth to introduce stress as a legitimate factor for you to consider in other decisions growing out of this incident.
>
> I am advised and I believe, however, that the question of stress, as related to the venting plan, is directly linked to the question of its safety, and that the consensus finding that the plan poses no radiation threat to public health should, in itself, substantially reduce any stress that might have accompanied it.
>
> UCS also recommends that you consider two alternative venting plans described in its report, and that you reconsider two non-venting plans previously rejected by your staff. I am sure you will give due consideration to those recommendations. I do urge that any new assessments be completed as promptly as possible. I am advised and believe that the sooner this matter is resolved, the sooner any stress related to it will be dissipated.
>
> I recognize that part of the delay already experienced has been due to my effort to be assured of the safety of venting. I now have that assurance, and I feel that a safe cleanup plan should be implemented as quickly as possible.
>
> Should you proceed with the venting proposal advanced by your staff, be assured that I am prepared to support that decision. To minimize stress, I am prepared to commit all of the resources at my disposal to assure the residents of the area, as I am now persuaded, that this plan is, indeed, a safe one....

In his letter, the Governor noted that the UCS had recommended consideration of two alternative purging plans as well as consideration of the Cryogenic Processing System and the Selective Absorption Process System (Ref. 3). In preparing this final Environmental Assessment, the NRC staff has evaluated the two alternative purging plans suggested by the UCS and has also reconsidered use of the Cryogenic Processing System and the Selective Absorption Process System.

The first of UCS' proposed plans would use a tethered balloon to support a 2000-foot-high reinforced fabric stack, a discussion of which is given in Section 6.2.5. This technique is unique and untried, as stated by UCS.

In general, the staff finds the UCS proposal technically workable and probably capable of being implemented within a year from the time the decision to use it was made. However, the staff has examined Three Mile Island for unobstructed ground and air space to launch a tethered ballon. Adequate unobstructed land recommended for the ballon launch is not readily available on the island without substantial modification to the site.

The second proposal of UCS was that the reactor building atmosphere be heated in an incinerator and discharged through a 250-foot-high stack. The staff evaluated this proposal in Section 6.2.5. Reconsideration of the Cryogenic Processing and Selective Absorption Process Systems are contained in Sections 6.6 and 6.7, respectively. Having evaluated these proposals, the staff continues to believe that the Kr-85 should be purged to the environment through the hydrogen control system.

Finally, the staff and the Commonwealth of Pennsylvania would have to ascertain the psychological impact on the nearby residents regarding the Kr-85 purging techniques proposed by the UCS. This difficult task was recognized by UCS as a valid concern in its report to the Governor.

As enclosures to a subsequent letter, the Governor of Pennsylvania provided copies of the various reports and assessments he had referred to in his previous letters and stated that the joint press release which he had developed with the UCS contained a clarification regarding the first recommendation on page 57 of the UCS report. The subject UCS recommendation stated:

> UCS recommends against any procedure that would result in citizens in the area around TMI being deliberately exposed to radiation from the plant at levels comparable to those expected from the Met Ed/NRC venting proposal.

Dr. Henry W. Kendall, UCS chairman, said the organization ultimately decided to recommend against implementation of the existing Met Ed/NRC venting plan, but he emphasized that this was primarily because of the stress problem.

The enclosed report of The Governor's Commission on Three Mile Island stated:

> *In light of our review of the alternative risks, this Commission urges the NRC to make a prompt decision concerning the proposed venting of the Unit 2 containment building atmosphere. Avoidance of this decision by the NRC is unacceptable. This Commission would not oppose an NRC decision to vent the krypton gas, provided that dose levels projected in the environmental impact assessment are acceptable. This position is based on a careful review of the best evidence available at this time.* (emphasis in original)

An enclosed memorandum to the Governor from the Pennsylvania Department of Environmental Resources stated that they had concluded that controlled purging using the hydrogen control system, as recommended by the NRC staff, was the preferred alternative for removing the krypton from the reactor building atmosphere.

An enclosed letter to the Governor from the Pennsylvania Department of Health recommended that in an effort to minimize stress, both present and accumulative, purging of the krypton from the reactor building be accomplished as soon as possible and in as brief a time period as possible.

An enclosed letter to the Governor from the Pennsylvania Department of Public Welfare stated that making a decision on purging and proceeding in a responsible fashion could in the long run minimize stress and reduce the potential for anxiety and depression among the population that lives near TMI.

9.2.6 State of Maryland.

The State of Maryland responded with two sets of comments. Their first response addressed the staff's recommendation in the basic Environmental Assessment (NUREG-0662), while their second response addressed Addenda 1 and 2 of NUREG-0662. In their first response (March 31, 1980), the State of Maryland agreed with the NRC staff recommendation that purging the reactor building atmosphere to the environment is the best available option. They did, however, recommend that real-time environmental and meteorological monitoring be used for dose-rate monitoring and reduction during purging operations to ensure that the offsite doses are estimated accurately and minimized. They also stated this was the proper time to make a decision regarding the decontamination of the reactor building atmosphere and that this action should be considered apart from the Programatic Environmental Impact Statement being prepared by NRC on all TMI-2 decontamination activities. They note that no benefit would be served by a delay and that, instead, delaying the decision would result in "a substantial loss." In their second response (April 22, 1980), they stated that the fast purge described in Addendum 2 of NUREG-0662 (a five-day purge over a two-week period) does not offer any net psychological advantage and that this option should be rejected in favor of a purge program which would use real-time meteorological data to minimize the highest offsite dose.

9.2.7 Member of the Pennsylvania House of Representatives.

One member of the Pennsylvania House of Representatives submitted as a comment a letter he had sent to all elected officials in his legislative district requesting that they join him in his call to come together and furnish the leadership necessary to accomplish a safe and expeditious cleanup at TMI. He also submitted several responses he had received in support of his call. Another member submitted a letter in which he stated: "Vent it!"

9.2.8 Commissioners of Cumberland County, Pennsylvania.

The Commissioners of Cumberland County, Pennsylvania, submitted a resolution supporting the recommended purging alternative. Their resolution stated that it is in the public interest to provide for the health and welfare of the people of Cumberland County by cleaning up TMI as soon as possible and that "the Government" should exert the necessary leadership to accomplish this action.

9.2.9 Middletown Borough Council, Middletown, Pennsylvania.

The Middletown Borough Council passed a resolution in support of purging the krypton-85 gas into the atmosphere. This resolution stated: "this council supports the venting (of krypton-85 gas in the atmosphere) as recommended by the NRC staff and calls for implementation as quickly as possible."

9.2.10 Borough of Royalton, Pennsylvania.

The Borough of Royalton, Pennsylvania submitted a resolution supporting the recommended purging alternative and the cleaning up of TMI as soon as possible. This resolution stated that their support was based on determinations by the NRC and EPA staffs that it is safe and proper to purge the Kr-85.

9.2.11 National Council on Radiation Protection and Measurements (NCRP).

The NCRP, in addition to the UCS, was specifically requested by the Governor of Pennsylvania to review the proposed purging operation. The NCRP submitted a response in which they stated:

> At the request of Governor Thornburgh of Pennsylvania, the National Council on Radiation Protection and Measurements (NCRP) has examined scientific material relating to the health effects of krypton-85, updated its Report No. 44 on krypton-85 published in 1975, and estimated the doses to the public and the risks associated with them for the amounts of krypton-85 expected to be released as a result of the proposed venting at the Three Mile Island nuclear power plant. The findings are that the maximum doses likely to be received by any person are very small.
>
> Superficial beta radiation to the skin is the primary potential health concern; however, in the total population within 50 miles no cases of skin cancer would be expected from the doses likely to be received. The risk to the maximally exposed individual member of the population at the plant boundary is estimated to be equivalent to the risk of skin cancer resulting from exposure to a few hours of sunlight, which is known to be the principal cause of skin cancer in the general population.
>
> The dose expected from the penetrating radiation is about 100 times less than that from the superficial radiation and the risk of inducing cancer is correspondingly smaller.
>
> The NCRP concludes that the exposures likely to be received as a result of venting are not a valid basis for concern with respect to health effects.

9.2.12 Natural Resources Defense Council (NRDC).

The NRDC provided a response by phone in which they supported the recommended purging operation by stating:

> Provided that the amount of radioactive materials to be vented are what they are reported to be (for example in NUREG-0662), and provided that the venting procedures are appropriately conducted, then the public health risks (somatic and genetic consequences) associated with venting the TMI-2 containment are not significant, that is, sufficient to warrant exclusion of this option.

9.2.13 Other Comments Supporting Controlled Purging.

In addition to the comments from these government agencies, officials, and scientific organizations, comments supporting the recommended purging alternative were also received from approximately 30 nongovernmental organizations. These included the Pennsylvania Chamber of Commerce, Lebanon Valley Chamber of Commerce, Greater

Harrisburg Area Chamber of Commerce, York Area Chamber of Commerce, Hanover Area Chamber of Commerce, Lancaster Association of Commerce & Industry, Manufacturers' Association of York, Pennsylvania, Greater and Central Pennsylvania Building and Construction Trades Council, Harrisburg-Hershey Area Tourist Promotion Agency, Harrisburg Hospital, American Association of Meat Processors, and various businesses in the TMI area, and approximately 150 private individuals and members of the professional community. Those commenting typically recommended that controlled purging be performed soon to permit continuation of the required cleanup activities.

9.2.14 Science Applications, Inc. (SAI).

At the request of the Commission, the NRC Office of Policy Evaluation (a Commission staff office), contracted with SAI to perform an independent technical evaluation of the purging alternative and Selective Absorption Process (Ref. 43). SAI's conclusions and recommendations were:

> From the points of view of feasibility, effectiveness practicality and the health and safety there is little to choose between the two alternatives.
>
> From the point of view of psychological stress on nearby populations, purging is the best alternative because it can be carried out in the least time with the fewest newsworthy incidents.
>
> From the points of view of schedule and cost, controlled purging is the best alternative because it is cheaper and can be started within days.
>
> Therefore it is our opinion that the SAP should not be adopted as a substitute for controlled purging.

9.3 Comments Opposing the Recommended Purging Alternative

Approximately 500 responses opposing the purging alternative recommended by the NRC staff were received. Included in these comments was a resolution by the County Commissioners of Dauphin County, Pennsylvania, opposing the release of the krypton-85. The reasons stated for their opposition were

> (a) the health of humans, animals and plants nearby cannot be fully guaranteed, (b) the full health implications of low level radiation exposure are not known, (c) health studies on human thyroids and various ailments afflicting animal life have not been completed to determine what effect, if any, previously released low level radiation has already had on humans and animals in the TMI area, (d) other options remain for the removal of the krypton-85 which have not been assessed independently by experts outside the NRC or Metropolitan Edison Company, (e) experience of the last thirty years from radiation exposure to indigenous populations near nuclear sites indicates clear health risk and resultant increased health problems from varying exposure levels to radioactive particles, (f) radiation and exposure measurement standards currently being used by the NRC and Metropolitan Edison Company are based on experiments and standards discredited by recently completed Heidelburg Studies and serious questions as to their accuracy and validity therefore exists in the scientific community.

The lower Swatara Board of Commissioners, Dauphin County, Pennsylvania, passed a resolution initially stating opposition to the purging into the atmosphere but further stating that they would accept the final recommendation of the Union of Concerned Scientists.

The Newbury Township Board of Supervisors, York County, Pennsylvania, also submitted a resolution which opposed the release of krypton-85 into the atmosphere; however, no specific reasons for their opposition were provided.

The Mayor of Lebanon, Pennsylvania, submitted a statement opposing the purging alternative and urging that alternative cleanup methods, which would not release radioactive material into the atmosphere, be employed without delay.

A member of the House of Representatives of the Commonwealth of Pennsylvania submitted a response in which he requested that the recommended purging operation be delayed at least until an independent assessment could be performed. The Union of Concerned Scientists was suggested as a possible organization to perform such an assessment.

The TMI Legal Fund submitted a response in which they stated their opposition to the recommended purging operation. They summarized their opposition into the following three concerns:

1. There is no emergency at hand. Data may be collected and containment facility equipment may be inspected and maintained without removal of the krypton-85 gas. There is adequate time to implement an alternative system for krypton-85 removal from the containment building atmosphere.

2. Venting of krypton-85 gas into the air which surrounds TMI-2 carries definite genetic and carcinogenic risks to the people of nearby communities. For a population which has already endured severe psychological stress, the proposed venting will only exacerbate this state of stress.

3. The proposed venting cannot be controlled due to meteorologic uncertainty. The monitoring as described by the NRC is incapable of providing sufficient information for the protection of people in communities surrounding TMI-2.

They also urged that data collection be initiated, that the containment building equipment be inspected and maintenance begun at TMI-2, but that the krypton-85 gas be retained until an alternative system has been installed for its safe and efficient removal.

The TMI Legal Fund response also stated that (1) the draft Environment Assessment did not adequately evaluate the potential health effects of the purging operation, (2) an independent assessment of the purging operation should be obtained, (3) the segmentation of the reactor building atmosphere decontamination effort from the Programmatic Environmental Impact Statement was an illegal action, (4) the monitoring program and criteria were insufficient, and (5) the krypton being approximately five times denser than air will therefore settle into low-lying areas such as valleys and basements in the absence of adequate convection.

In addition to the above-noted comments, additional comments opposing the recommended purging alternative were received from approximately 10 nongovernment organizations (including the Office of the Provost, Capital Campus, the Pennsylvania State University; the National Audubon Society; Taxpayers Association of Lackawanna County; Heathcote Valley Alliance; Air and Water Pollution Patrol; Lehigh-Pocono Committee of Concern; and various businesses in the TMI area); and from approximately 485 private individuals. Their reasons for opposing the recommended purging operation included the following: (1) that the public be exposed to no additional radioactive effluents from TMI, (2) that one or more of the other alternatives for decontamination evaluated in the draft Environmental Assessment be used to eliminate or minimize the release of Kr-85 to the environment, (3) that there is no perceived or recognized need for the decontamination (several persons suggested that the facility be entombed in its present condition), (4) that any purging operation be delayed at least until students are released from the schools for summer vacation, (5) that any purging operation should be accompanied by a more extensive monitoring program, and (6) that an independent assessment of the recommended purging operation be first performed by a citizen-dominated group.

9.4 NRC Staff Responses to Comments Opposing the Recommended Purging Alternative

A detailed discussion of the health effects associated with the various alternatives for decontaminating the reactor building atmosphere has been incorporated into Section 7.0 of this document. The NRC staff has determined that the potential for adverse radiological health effects to the public due to utilization of any of the decontamination alternatives is negligible and that the public health and safety will not be adversely affected by the purging operation. Therefore, since the recommended purging operation can be accomplished without significant risk to the health and safety of the public, and since the purging operation can be implemented immediately as recommended in Section 5.0, the NRC staff recommends that use of the purging alternative be authorized soon, rather than waiting for installation of one of the other decontamination methods.

At the request of Governor Thornburgh of Pennsylvania, the public comment period for NUREG-0662 and its two Addenda was extended to May 16, 1980. The reason for the Governor's request was to permit sufficient time for completion of an independent assessment of the decontamination operation by the Union of Concerned Scientists (UCS). The Governor specifically requested the UCS to perform such an assessment so that he could receive information from the broadest range of knowledgable sources available. In their report to the Governor, the UCS stated:

> UCS concluded that direct radiation-induced health effects from exposure to Kr-85 even from the Met Ed/NRC proposed venting would be absent. These conclusions are similar to those reached by the NRC and Met Ed.

In Addendum 2 to NUREG-0662, the NRC staff evaluated and recommended a variation in the purging alternative which would permit the purge to be completed in an elapsed purging time of approximately 120 hours over a two-week period, provided it was performed before about mid-May to take advantage of expected favorable meteorology. However, because of the delays to permit comments on decontamination alternatives, the NRC staff no longer recommends this variation in the purging alternative. The extended comment period has also delayed the purging operation until at least the beginning of the school summer vacation period, a delay requested by several commentators. However, for the reasons described in Section 5.0, the NRC staff now recommends that the purging alternative evaluated in Section 6.2 be accomplished without further delay.

Although several commentators did not recognize or acknowledge the need for decontaminating the reactor building, the NRC staff believes that it is imperative that this action be taken. The staff's reasons for believing that this action must be taken are discussed in detail in Section 5.0. This staff position was also supported by the UCS in their report to the Governor of Pennsylvania:

> The Union of Concerned Scientists (UCS) Study Group believes that ultimate decontamination of the plant is an absolute necessity. Decontamination must include complete removal of the damaged fuel rods and of the contaminated water in the containment sump and elsewhere. The plant cannot be sealed and walked away from. This would constitute a negligent disposal means for a very large quantity of radioactivity. Important quantities of these toxic materials would ultimately find their way into the environment during the tens or hundreds of thousands of years that some of them will remain hazardous.
>
> Accordingly, UCS has concluded that the krypton must be removed from the TMI reactor building so that an orderly program of decontamination can be undertaken. The problem is how to do this in a manner which protects the safety of the workers who may be exposed to the krypton and also safeguards the physical and mental health of members of the public who may also be exposed.

The UCS did however conclude that in their opinion a delay in removal of the krypton of up to a year and a half would not pose an undue risk to the health and safety of the public. Such a delay would of course postpone any substantive progress in the overall cleanup program and as stated in Section 5.0, the NRC staff believes that the cleanup program should progress in a timely manner.

The radiological monitoring programs for the TMI site and surrounding area consist of several programs described in Section 8.0. In the opinion of the NRC staff, these programs with EPA having the lead for federal agencies, as designated by the Executive Office of the President) will provide an adequate monitoring of the recommended purge operation. The on-going monitoring programs will be supplemented by the DOE program described in Section 8.0 if the purging alternative is approved. A cadre of about 50 local residents have been trained to participate in the DOE monitoring program. EPA will supplement its existing fixed monitoring stations with mobile units positioned in areas of expected maximum dose. Reports of measurements will be made daily by EPA to the public and media.

Control of the purging operation will be accomplished through frequent (at least hourly) monitoring of the existing meteorological conditions and reactor building effluent flow rate. The DOE meteorological forecasting and monitoring capabilities will utilize this information in conjunction with radiological monitoring program results and will be communicated to the control room to assure that the cumulative doses to the public in any sector will not exceed those in Section 7.0 of this assessment.

The NRC staff disagrees with allegations that separating the reactor building atmosphere decontamination effort from the Programmatic Environmental Impact Statement was illegal. This is supported by CEQ's comments, noted in Section 9.2.1. The basis for the staff position is the Commission's November 21, 1979 Statement of Policy and Notice of Intent to Prepare a Programmatic Environmental Impact Statement, which clearly reserved the option to authorize such an action when it stated:

> The development of a programmatic impact statement will not preclude prompt Commission action when needed. The Commission does recognize, however, that as with its Epicor-II approval action, any action taken in the absence of an overall impact statement will lead to arguments that there has been an inadequate environmental analysis, even where the Commission's action itself is supported by an environmental assessment. As in settling upon the scope of the programmatic impact statement, CEQ can lend assistance here. For example should the Commission before completing its programmatic statement decide that it is in the best interest of the public health and safety to decontaminate the high level waste water now in the containment building, or to purge that building of its radioactive gases, the Commission will consider CEQ's advice as to the Commission's NEPA responsibilities. Moreover, as stated in the Commission's May 25 statement, any action of this kind will not be taken until it has undergone an environmental review, and furthermore with opportunity for public comment provided.

Although krypton gas is approximately five times denser than air, it will not settle into low-lying areas or basements as suggested by several commentators. The physical properties of gases (as expressed in the physical laws that describe the dispersion of gases) prevent the settlement of low concentrations of denser gases into low-lying areas. The krypton concentration in the reactor building atmosphere is at approximately the same concentration as naturally occurring krypton in the earth's atmosphere. The naturally occurring krypton is uniformly distributed throughout the earth's atmosphere as is the krypton in the reactor building's atmosphere; in neither case has the krypton settled into low-lying areas.

9.5 Other Comments on the Recommended Purging Alternative

9.5.1 Introduction

The NRC staff received approximately 105 responses providing either specific comments on the five alternative methods evaluated in NUREG-0662 for decontaminating the reactor building atmosphere or suggestions for additional methods for accomplishing the required decontamination.

9.5.2 Member of Congress

A Member of Congress from Pennsylvania submitted a comment opposing the purging operation and recommending that the Selective Absorption Process be used. This recommendation was based upon the Congressman's belief that the Selective Absorption Process could be placed into operation in six months and that except for the purging alternative, it would be the least expensive alternative to implement. The six-month implementation time was based on a review performed, at his request, by a member of the staff of the U.S. House of Representatives Committee on Science and Technology. The Congressman also requested Oak Ridge National Laboratory (ORNL) to reassess their time estimate for when a Selective Absorption Process system of adequate capacity could be placed into operation at TMI. ORNL subsequently reported that with "best efforts" being exerted by all concerned parties, such a system could be operational at TMI in 13 months. The TMI Program Office also requested an assessment of the proposed schedules for fabrication and installation of such a system by the Reactor Construction and Engineering Support Branch of the NRC's Office of Inspection and Enforcement. The Reactor Construction and Engineering Support Branch concluded that the six-month schedule proposed by the staff of the Committee on Science and Technology was unrealistic and that the 13-month ORNL schedule was optimistic. They further concluded that their minimum schedule estimate would be 16 months with their best estimate being even longer.

9.5.3 U.S. Department of the Interior

The Department of the Interior commented that the draft report did not discuss what effects, if any, the proposed release of krypton would have on fish and wildlife resources and their habitats. As noted in Section 7.1, the recommended purging operation will have no significant effect on fish or wildlife resources or on their habitats.

9.5.4 MITRE Corporation

The MITRE Corporation submitted a comment proposing to use a cryogenic air separation plant for removing the krypton from the reactor building atmosphere. This proposed method would be similar in operation to the Cryogenic Processing System described and evaluated in Section 6.6. An evaluation of the proposal submitted by the MITRE Corporation and the NRC staff reasons for not recommending its use are included in that section.

9.5.5 International Business Machines Corporation (IBM)

A technical report copyrighted in 1979 by IBM was submitted as a comment. This report, "Encapsulation of Radioactive Noble Gas Waste in Amorphous Alloy," describes a method for long-term storage of Kr-85. Use of this storage method requires that the Kr-85 first be separated from the reactor building atmosphere by use of a cryogenic distillation tower similar to the Cryogenic Processing System described in Section 6.6. As noted in that section, construction and operation of such a system would require a minimum 20 month delay which for the reasons discussed in Section 5.0 of this document are considered unacceptable. Therefore, no further actions have been taken on this comment.

9.5.6 Pennsylvania State University

The Pennsylvania State University submitted a comment suggesting the use of an oxygen liquefaction unit. This unit would concentrate more than 99% of the krypton in the liquid oxygen product. The liquid oxygen would then be passed through a bed of adsorbent material such as silica gel where the krypton would be selectively adsorbed. The separation of the krypton from the oxygen could be done either onsite or offsite. Such an oxygen liquefaction unit would be similar to the Cryognic Processing System evaluated in Section 6.6. Due to the time required for construction and operation of such a unit (a minimum of 20 months), use of this method is not recommended.

9.5.7 Science Applications, Inc. (SAI)

A comment in the form of a proposal to remove the krypton from the TMI-2 reactor building atmosphere was received from SAI. The proposed method would use a selective adsorption process. In their proposal, SAI estimated that such a system would require nine months for design, construction and checkout. Due to this delay in system availability, the NRC staff does not recommend further consideration of this proposal.

9.5.8 Environmental Policy Center

The Environmental Policy Center submitted a comment suggesting that rather than decontaminating the reactor building, it and the radioactive wastes within it should be entombed. However, since it is imperative that the damaged fuel be removed from the reactor to prevent either its potential recriticality or eventual escape to the environment over very long time periods, the entombent suggestion is not considered a viable alternative.

9.5.9 Environmental Coalition on Nuclear Power (ECNP)

A comment from the ECNP recommended that rather than implementing the purging alternative, the krypton be removed from the reactor building atmosphere by one of the other alternatives (charcoal adsorption, gas compression, cryogenic processing, or selective absorption) and then transferred to some unpopulated place for release under controlled conditions. Because of the negligible adverse radiological health effects of the proposed purging operation, and because of the delays (16 months or longer) associated with the implementation of any of the other decontamination alternatives which do not purge, the NRC staff continues to recommend that the purging alternative be selected as the method for decontamination of the reactor building atmosphere.

The ECNP further stated that if their recommendation was not implemented, there were at least two other alternatives which have not been evaluated by the NRC staff: (1) transfer the gas (the TMI-2 reactor building atmosphere) to the TMI-1 reactor building and store it there until removal could be accomplished by one of the other decontamination alternatives, and (2) purge the TMI-2 reactor building atmosphere to the environment rapidly, as in a "puff release."

The NRC staff has reviewed these suggested alternatives and considers both of them unacceptable for the following reasons. As noted in Section 6.2, to reduce the radioactivity in the TMI-2 reactor building atmosphere to maximum permissible concentrations would require the transfer of about 23 million cubic feet of air. This transfer would, in turn, pressurize the TMI-1 reactor building to 170 psig, a pressure significantly in excess of its design pressure of 60 psig. Therefore, transfer of the gas is not a viable alternative.

In preparing Addendum 2 to NUREG-0662, the NRC staff evaluated variations in the purging alternative in an attempt to minimize the duration of the recommended purge operation. In this evaluation, the staff determined that it would not be advisable to purge the reactor building as rapidly as physically possible since such a purge would most probably result in beta skin doses in unrestricted areas in excess of the design objectives of 10 CFR Part 50, Appendix I (Ref. 15).

9.5.10 Pennsylvania Dutch Visitors Bureau (PDVB)

The PDVB suggested that all future news releases relating to releases of radioactivity contain an explanation (in layperson's terms) of physiological and environmental impacts. The NRC TMI Program Office has issued an easy-to-understand report that answers questions most frequently asked about the proposed purge of krypton from the reactor building. This report states in layman's terms the potential health impacts likely to occur when the krypton is released. Copies of the report, "Answers to Questions about Removing Krypton from Three Mile Island, Unit 2 Reactor Building "(NUREG-0673) are available free of charge by writing to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20556. In addition, Section 1.0 was written to provide a fairly complete discussion of the entire final assessment report for the layperson. Section 7.0 of the final assessment also describes the health effects of the various alternatives for decontaminating the reactor building atmosphere.

9.5.11 Hershey Entertainment & Resort Company (HERCO)

HERCO requested that the purging operation be scheduled (consistent with safety) either prior to or just after the peak June - August tourism season. For the reasons described in Section 5.0, the NRC staff recommends that the purging operation be performed soon. The information in Section 7.0 is provided to alleviate public concerns about the health effects of the purging operation, which have been determined to be negligible.

9.5.12 Oak Ridge National Laboratory (ORNL)

ORNL suggested a possible mechanism for alleviating some of the public concern regarding the proposed purge operation. Their suggestion was to encourage and fund local radiation monitoring efforts for the duration of the planned release. They further suggested that the Commonwealth of Pennsylvania should be requested to assist or oversee this effort. The DOE monitoring program described in Section 8.0 will function essentially as suggested by ORNL. Approximately 50 local residents have been trained to participate in monitoring the recommended purge operation.

9.5.13 Councilman and Director Department of Public Safety, City of Lebanon, Pennsylvania

The Councilman and Director Department of Public Safety, City of Lebanon, Pennsylvania recommended a delay in the purging operation and asked for "a stronger, more concerted effort to establish a factual, responsible, public information source which may enjoy a greater degree of public confidence than that now experienced by the NRC. The Governor's request for participation by the Union of Concerned Scientists may be a step in this direction." Such a delay was granted and the UCS submitted their report to the Governor of Pennsylvania on May 15, 1980. The Governor subsequently stated that he was prepared to support the purging decision if the Commission proceeded with the purging proposal advanced by the NRC staff. He further stated: "To minimize stress, I also am prepared to commit all of the resources at my disposal to assure the residents of the area, as I am now persuaded, that this plan is, indeed, a safe one."

9.5.14 West Shore School District

The West Shore School District requested that approval of the purging operation be postponed until after the schools in the TMI area have closed for the summer. They further stated that most of these schools will close for the summer during the week of June 9. The decision to extend the public comment period on NUREG-0662 to May 16, 1980 effectively granted this request.

9.5.15 Regional Planning Council

The Regional Planning Council for the Baltimore, Maryland area commented that while in previous statements it has supported the position that there should not be a release of radioactive material from the cleanup process before the preparation of an Environmental Impact Statement, it does recognize the need for timely action by the NRC when it finds that public safety requires release of material before the EIS is completed. They also commented that the Environmental Assessment fails to mention a deadline for release of the gas. They recommended that the purge operation be delayed until the Union of Concerned Scientists study requested by the Governor of Pennsylvania was completed. Since the UCS study has now been completed, the NRC staff recommends, for the reasons stated in Section 5.0, that the purging operation be performed soon and prior to completion of the Programmatic Environmental Impact Statement.

They also requested that Maryland health officials be notified in advance of the purge operation so that monitoring stations can be established by Maryland officials. The NRC staff intends to provide at least a ten-day advance notice to all pertinent officials, to the press, and to the public for the controlled purging operation.

9.5.16 Additional Comments from Individuals

In addition to the above-noted comments, approximately 90 additional responses were received from individuals who provided specific comments on the alternative methods evaluated in NUREG-0662 or suggestions for additional methods for accomplishing the required decontamination. The additional comments or suggestions were broad ranging. They included suggestions (1) to purge the reactor building atmosphere into balloons and release the contents at high elevations, (2) to evacuate the residents in the TMI area during the purging operation, and (3) to modify the charcoal adsorption process to minimize the quantity of charcoal required. Some persons urged that NRC staff members and officials be present in the TMI area during the purging operations, expressed concern about possible releases of other radioactive materials, questions differences in the quantities of Kr-85 reported by the licensee (44,000 curies) and by the NRC staff (57,000 curies) and worried that additional quantities of fission products are continuing to be generated. One person recommended that the cleanup operation be performed by the Naval Reactors Branch of DOE. Several other persons suggested that any necessary maintenance and repairs within the reactor building could be performed by workers dressed in protective clothing without prior removal of the Kr-85.

A number of letters suggested that the krypton gas be placed in high-altitude balloons and transported for release high in the atmosphere. Although high- altitude balloons are technically feasible as an alternative to controlled purging, their use could increase the risk of an uncontrolled release that could result in higher radiation exposures to the workers and the public than would occur from the alternatives discussed in this report.

A large number of balloons would be required and they would have to be of immense volume because krypton-85 is a heavier-than-air gas which would require the addition of helium gas or lift capability to the balloons as a volume ratio of approximately 30 times that of krypton-85. Moreover, the probability for a balloon burst is fairly high. Based on the National Oceanic and Atmospheric Administration experience with high-altitude weather balloons, the chance of no balloon burst is in the range between 75 to 85%, but can drop as low as 50% during periods of gusty winds. This probability, coupled with the large number of balloons that would be necessary (assuming krypton-85 is transported as a gas), would increase the overall probability of a premature balloon burst. Solutions would then need to be devised for retrieval and disposal of the contaminated balloons. Finally, use of balloons for transporting radioactive gas may further aggrevate the psychological stress of some residents in the TMI area due to the obvious visibility they would provide. In summary, since the radiological health effects associated with the recommended purging operation are negligible, and since the probable disadvantages outweigh the advantages of using balloons in transporting and remotely releasing the Kr-85 gas, use of this concept is not recommended.

Recommendations that local residents be evacuated during any purging operation were based on the assumption that an evacuation would protect residents from any radiological hazards associated with the release of the Kr-85. However, as discussed in Section 7.0, the adverse radiological health effects of the recommended purging operation will be negligible and, therefore, evacuation of the local residents is neither required nor recommended.

The suggested variation in the charcoal adsorption process recommends that three containers of charcoal to be used. In this variation, the reactor building atmosphere would be filtered, dried, refrigerated, and passed over refrigerated charcoal until krypton breakthrough occurred in the first container. The krypton in this first container would then be desorbed by admitting heated and humidified air. The desorbed krypton would be transferred to a second refrigerated container of charcoal for storage. The adsorption and desorption in the first container would then be repeated for several cycles. Although the charcoal loses its ability to adsorb krypton with increasing humidity, this ability is only decreased in magnitude, it is not eliminated. Significant holdup is still obtained at high humidity, and desorption would not be easy. Therefore, transfer of krypton, as the proposal suggests, cannot be expected as easily as stated. Since this concept is the basis for the entire proposal, the rest of the proposal simply does not follow and its further consideration is not recommended.

Several suggestions were made that NRC staff members and officials be present in the TMI area during the purging operations. The reasons for these suggestions included that their presence would be a demonstration of confidence in statements by the NRC staff that the radiological health effects are negligible. Members of the NRC professional staff would be at, and in the vicinity of, TMI during purging operations to oversee these operations.

Concerns were expressed regarding the possible releases of radioactive materials other than Kr-85 from the reactor building, especially radioactive isotopes of cesium and strontium. As noted in Section 4.0, the concentrations of airborne radioactive particulate matter in the reactor building atmosphere is low and the purge exhaust filter system will remove essentially all of the particulate matter in the exhaust stream, thereby ensuring that there will be no significant dose effects associated with the releases of other radioactive material.

Concerns were also expressed that additional quantities of fission products are continuing to be generated or released to the reactor building atmosphere and that this activity may be released during the purge. These concerns were based upon the variations between source terms used by the licensee in his submittal of November 13, 1979 (Ref. 1) and those used by the NRC in NUREG-0662 (March 1980). As noted in Section 4.2, these variations were not due to the generation of additional fission products or their release to the reactor building atmosphere but were due to improved techniques in sampling and analyzing the samples.

A suggestion was made that by Presidential Executive Order, complete responsibility for the cleanup program at TMI be assigned to the Naval Reactor Branch of DOE and that the cleanup decisions should be removed from public debate. The stated bases for these suggestions were that the cleanup action needs to progress immediately and that the TMI-2 plant was not designed to house large amounts of gaseous krypton, radioactive water, or damaged nuclear fuel for long periods of time. Although the TMI-2 facility was not specifically designed to accommodate all of the conditions encountered during and following the accident, it is now and is expected to continue to isolate the radioactive wastes from the environment provided necessary actions are taken on a timely basis. (See Section 5.0). The licensee, with appropriate support from the NRC, EPA and DOE professional staff, has sufficient expertise to perform the necessary cleanup operations. Therefore, there is no present need to assign the cleanup operation to another organization. Moreover, the U.S. Congress has enacted legislation making the NRC responsible for licensing activities pertaining to civilian nuclear power reactors and NRC regulations allow for public participation in the licensing process.

Several comments were made to the effect that any necessary maintenance and repairs within the reactor building could be performed by workers dressed in protective clothing prior to removal of the Kr-85. However, as noted in Section 5.0, only preliminary measurement and planning activities can be performed in the reactor building prior to the removal of the Kr-85. Therefore, the Kr-85 must be removed to permit any maintenance or repair activities within the reactor building.

10.0 Public Information Activities

In an effort to better inform the public in the area around Three Mile Island about the contents of the draft Environmental Assessment (NUREG-0662, and Addenda 1 and 2), NRC has conducted 38 informational meetings and activities. The staff also issued an easy-to-understand report that answers frequently asked questions about removing the krypton from the reactor building. Copies of the report, "Answers to Questions about Removing Krypton from the Three Mile Island Unit 2 Reactor Building" (NUREG-0673), are available free of charge by writing to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Most of the meetings held were planned by the NRC, although some were organized by other interested groups, at which NRC officials were invited participants. Members of the U.S. Environmental Protection Agency and the Pennsylvania Department of Environmental Resources (DER) were usually invited participants at these meetings. EPA officials outlined their agency's program and responsibilities for environmental monitoring in the vicinity of the TMI site, while state DER personnel explained the community monitoring program and other state functions related to the clean-up of TMI Unit 2. At these meetings, NRC officials expressed their willingness to meet with other groups of people who had an interest in receiving additional information on the Environmental Assessment or clean-up operations at Unit 2.

This effort of communicating with the public fell into three broad categories:

- 15 public meetings and meetings with interested citizens groups,
- 16 meetings with elected officials, and
- 7 press conferences and appearances on public information radio and television shows.

10.1 Public Meetings and Meetings with Interested Groups

On March 19, 1980, NRC conducted a public meeting in Middletown to inform local citizens of the contents of the draft Environmental Assessment. Following this initial meeting, NRC officials attended similar gatherings in surrounding communities at the request of state and local officials.

The NRC staff also met with a wide variety of interested groups which included:

- Chambers of Commerce
- Civic Service Organizations
- Medical Associations
- School Board Officials
- Religious Leaders
- Teacher Organizations
- Three Mile Island Alert

Meetings with the Capital Forward Group and Three Mile Island Alert were attended by Chairman Ahearne and Commissioner Hendrie, respectively, in addition to NRC staff participation.

10.2 Briefings for Elected Officials

In addition to meeting with Governor Thornburgh, Harold Denton, Director of the Office of Nuclear Reactor Regulation, and other members of the NRC staff met with various city officials from major metropolitan areas surrounding Three Mile Island. Meetings were held with the Commissioners and other officials from the four counties closest to TMI: Dauphin, Lancaster, York, and Lebanon. Five briefings were also conducted in different geographic locations for elected officials from the Boroughs and Townships which surround Three Mile Island.

10.3 Press Conferences and Television and Radio Appearances

Harold Denton held several press conferences in central Pennsylvania, one of which was held jointly with Governor Thornburgh to discuss the Environmental Assessment. John T. Collins, Deputy Program Director, TMI Program Office, appeared on several television and radio talk programs where listeners or panel members asked questions concerning the Environmental Assessment. These appearances by Mr. Collins were in addition to his numerous other television and radio interviews concerning a wide range of topics relating to activities at the TMI site.

11.0 References

1. Metropolitan Edison Company, "Three Mile Island Unit 2 Reactor Building Purge Program Safety Analysis and Environmental Report," Docket 50-320, November 13, 1979. (PDR)*

2. U.S. Nuclear Regulatory Commission, "Environmental Assessment for Decontamination of the Three Mile Island Unit 2 Reactor Building Atmosphere - Draft NRC Staff Report for Public Comment," USNRC Draft report NUREG-0662, March 1980. (DTIDC)

3. Union of Concerned Scientists, "Decontamination of Krypton-85 from Three Mile Island Nuclear Plant," A Report to the Governor of Pennsylvania, May 15, 1980. (PDR)

4. Letter from R. H. Vollmer, NRC, to R. C. Arnold, Metropolitan Edison Co., Subject: Reactor Containment Building Atmosphere Cleanup, Docket 50-320, December 18, 1979. (PDR)

5. Letter from J. T. Collins, NRC, to R. F. Wilson, Metropolitan Edison Co., Subject: Additional Information Request for Preparation of Environmental Assessment, Docket 50-320, December 18, 1979. (PDR)

6. Letter from R. F. Wilson, Metropolitan Edison Co., to J. F. Collins, NRC, Subject: Response to 33 Questions on Reactor Containment Building Atmosphere Cleanup, Docket 50-320, January 4, 1980. (PDR)

7. U.S. Nuclear Regulatory Commission, "Statement of Policy and Notice of Intent to Prepare a Programmatic Environmental Impact Statement." (PDR)

8. U.S. Nuclear Regulatory Commission, "Order by the Director of the Office of Nuclear Reactor Regulation," Docket 50-320, February 11, 1980. (PDR)

9. U.S. Nuclear Regulatory Commission, Rules and Regulations, Title 10, Code of Federal Regulations Part 20, Appendix B, Table I. (PL)

10. Metropolitan Edison Company, "Technical Evaluation Report for Submerged Demineralization System (SDS)," April 10, 1980. (PDR)

11. U.S. Nuclear Regulatory Commission, Rules and Regulations, Title 10, Code of Federal Regulations Part 50, "Licensing of Production and Utilization Facilities," March 1975, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion as Low as Practicable for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents." (PL)

12. U.S. Environmental Protection Agency, Rules and Regulations, Title 40, Code of Federal Regulations Part 190, "Environmental Standards for the Uranium Fuel Cycle," January 1977. (PL)

13. Three Mile Island Nuclear Station, Unit 2, Environmental Technical Specifications, Appendix B to Operating License DPR-73, February 8, 1978. (PDR)

14. U.S. Nuclear Regulatory Commission, Regulatory Guide 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable." (PDR, GPO)

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*For information on document availability, see Page 11-4.

15. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I." (PDR, GPO)

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(PDR) - USNRC Public Document Room, 1717 H Street, N.W., Washington, DC 20555. Available for inspection and copying for a fee.

(DTIDC) - Copies are available for sale from the Publications Sales Manager, Division of Technical Information and Document Control, USNRC, Washington, DC 20555. Single copies of draft reports are available free of charge from the same address.

(PDR, GPO) - Copies are available from the NRC PDR for inspection and copying for a fee, and from the U.S. Government Printing Office, Washington, DC 20402, Attn: Regulatory Guide Account.

(PL) - Available from a public library.

12. Glossary

Absorbed dose - The energy imparted to matter by ionizing radiation.

Anticipated Operational Occurrence - Miscellaneous conditions or actions such as equipment failure, operator error, administrative error, that are expected to occur that are not of magnitude great enough to be considered an accident.

Background radiation - Radiation arising from natural radioactive materials always present in the environment, including solar and cosmic radiation and radioactive elements in the upper atmosphere, the ground, building materials, and the human body. In the Harrisburg area the background radiation level is about 125 mrem per year.

Beta parcticles - Charged particles emitted from the nucleus of a atom, with a mass and charge equal in magnitude to that of the electron.

CFM - Cubic feet per minute

Control rod - A rod containing material that absorbs neutrons; used to control or halt nuclear fission in a reactor.

Core - The part of a nuclear reactor that contains the fuel (fissionable material). In a reactor like that at TMI, the region containing fuel-bearing rods.

Critical - Term used to describe the capability of sustaining a chain reaction at a constant level.

Cryogenic Processing - Low-temperatue separation processes whereby materials that are normally gases are isolated and recovered from other gases by liquifying them at low temperatures.

Cubic Centimeter (cc) - Unit for measuring volume. Approximately 947 cubic centimeters is equal to one U.S. quart.

Curie (Ci) - The special unit of radioactivity. Activity is defined as the number of nuclear transformations occurring in a given quantity of material per unit time.

Decay heat - Heat produced by the decay of radioactive particles; in a nuclear reactor this heat, resulting from materials left from the fission process, must be removed after reactor shutdown to prevent the core from overheating. See Radioactive decay.

Dose - Denotes the quantity of radiation or energy absorbed. For special purposes it must be appropriately qualified. If unqualified, it refers to absorbed dose. See Absorbed dose.

Dosimeter - Dose meter. An instrument that measures radiation dose. See TLD.

Gamma rays - Short-wave length electromagnetic radiation of nuclear origin emitted from the nucleus of an atom. A form of ionizing radiation.

Half-life - The time required for half of a given radioactive substance to decay.

HEPA - High-efficiency particulate filter.

Ionization - The process by which a neutral atom or molecule acquires a positive or a negative charge.

Ionizing Radiation - Any form of radiation that displaces electrons from atoms or molecules. The resulting atom or molecule is an ion. Ions become electrically charged as a result of this process.

Krypton-85 - An inert noble gas (it does not interact chemically with other chemical elements or compounds) with a half-life of 10.7 years.

LET - Linear energy transfer. A measure of the capacity of biological material to absorb ionizing radiation.

MDA - Minimum Detectable Activity. Minimum level of radioactivity detectable with monitoring instruments.

Meteorological dispersion factor (X/Q) - A factor (seconds/m^3) which accounts for site-specific meteorological data in relating the concentration (Ci/m^3) of radioactive materials, at a given location, to a release rate (Ci/sec) of radioactive material at another location.

Microcurie (mCi) - Unit for measuring radioactivity. One microcurie is one-millionth of a curie (1/1,000,000). See curie.

Millicurie (mCi) - Unit for measuring radioactivity. One millicurie is one-thousandth (1/1,000) of a curie.

Millirem (mrem) - One one-thousandth (1/1000) of a rem; see rem.

MPC - Maximum Permissible Concentration of radioactive exposure, as specified in Title 10 Code of Federal Regulations, Part 20, Table B.

Noble gases - Inert gases that do not readily react chemically with other elements. These gases include helium, neon, krypton, xenon, and radon.

Nuclear Regulatory Commission (NRC) - U.S. agency responsible for the licensing, regulation, and inspection of commercial, test, and research nuclear reactors, as well as nuclear materials.

Order of Magnitude - Within a factor of 10.

Person-rems - The sum of the individual doses received by each member of a certain group or population. It is calculated by multiplying the average dose per person by the number of persons. Consequently, the collective dose is expressed in person-rems. For example, a thousand people each exposed to one mrem would have a collective dose of 1 person-rem.

PSIG - Pounds per square inch gauge. A measure of the difference in pressure above or below normal atmospheric pressure.

rad - The basic unit of absorbed dose of ionizing radiation. A dose of one rad means the absorption of 100 ergs of radiation energy per gram of absorbing material.

Radiation - Energy in the form of rays (light, heat, X-ray, radio waves) sent out through space from atoms and molecules as they undergo internal change.

Radioactive decay - The spontaneous natural process by which an unstable radioactive nucleus releases energy or particles to become stable.

Radioactivity - The spontaneous decay of an unstable atom. During the decay process, ionizing radiation is usually given off.

Reactor (nuclear) - A device in which a fission chain reaction can be initiated, maintained, and controlled.

Reactor building - The structure housing the nuclear reactor. Also called containment building or reactor containment building.

Reactor vessel - The steel vessel containing the reactor core; also called pressure vessel.

Rem - A standard unit of radiation dose. Frequently radiation dose is measured in millirems for low-level radiation; 1,000 millirems equal one rem.

SCFM - Standard Cubic Feet Per Minute. "Standard" refers to standard conditions of pressure and temperature.

Selective Absorbtion Process - A separation process whereby a liquid is used to selectively absorb (separate) a selected material (gas) from a source gas stream (air).

Source Term - Defines an amount of radioactive material.

TLD (thermoluminescent dosimeter) - A solid-state device used to measure nuclear radiation doses. See Dosimeter.

Tritium - A radioactive isotope of hydrogen.

Wake-Cavity Effect - The region of turbulance immediately to the rear of a solid body, like a building, that is formed when wind currents flow over and around the object.

X/Q - See Meteorological Dispersion Factor.

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This final Environmental Assessment evaluates the environmental impacts of alternative methods for decontaminating the reactor building atmosphere at Three Mile Island, Unit 2 and incorporates comments on decontamination alternatives from Federal, State, and local officials and from private citizens and groups. The staff recommends that the reactor building be purged over a 60-day period.

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