MICHIGAN STATE UNIVERSITY

COLLEGE OF NATURAL SCIENCE · DEPARTMENT OF PHYSICS EAST LANSING · MICHIGAN · 48824

March 24, 1980

The Honorable Victor Gilinsky
Commissioner
US Nuclear Regulatory Commission
1717 H Street, N.W.
Washington, DC 20555

Dear Dr. Gilinsky:

Here is my report on the alternative methods for removing Krypton-85 from the atmosphere of the reactor building of Unit 2 at Three Mile Island. In preparing this report, I have studied the NRC Environmental Assessment as well as other relevant scientific and engineering literature. It's a hard problem and my conclusions are still tentative. I should like to get first-hand experience with the alternatives. Then I will be able to reconsider and firm up the conclusions.

The first part of this report is an introduction to the problem. The second part is a brief discussion of each of the five alternatives; they are discussed in order from most preferred, in my opinion, to least preferred.

I. Introduction

The problem we need to solve is how to decontaminate the atmosphere of the reactor building at TMI-2. The main contaminant is Kr-85, a radioactive inert gas. The resulting radioactivity concentration now is high, 1.0 $\mu C/cm^3$. The atmosphere must be cleared so that there can be free and safe access to the building to get on with the rest of the cleanup. We would like the decontamination to be safe, with minimal exposures to the public and to workers, and to be as inexpensive and quick as possible within these constraints.

cylinders of gas contained in a few bookcase-sized lead and concrete containers. Outside these containers the radiation will be undetectable. If the storage is carried out for 100 years (i.e. 9.3 half-lives) the total radioactivity will be down to 91 Ci. I believe that good quality stainless-steel cylinders and valves will last this long without significant deterioration.

II. Alternative Methods for Decontaminating the Reactor Building

I have tentatively concluded that the best method of those available is the Selective Absorption Process System and that the second best method is the Cryogenic Process System. The remaining methods are, in my opinion, all considerably less desirable than these first two. The Reactor Building Purge is, on balance, my third choice, the Charcoal Adsorption System is fourth, and the Gas Compression System is fifth. Each of these systems is discussed briefly below.

A. Selective Absorption Process System

The operating principle of this system is that Freon (CF_2Cl_2) absorbs noble gases. The idea is to run the reactor building atmosphere through a column of liquid Freon. The Kr-85 will be removed from the air, the decontaminated air is returned to the reactor building, and the Kr-85 may be isolated and concentrated.

In my opinion this system is probably the best alternative for these reasons: (1) The end product is radioactive Kr-85 in a few standard-sized gas cylinders. I believe that these can be relatively easily handled and stored safely as previously described. (2) It is a zero-release system, i.e. in principle no Kr-85 will get out to the atmosphere and thus there will be minimal offsite doses. (3) The system has already been extensively developed to a pilot-plant scale at Oak Ridge National Laboratory. The Oak

Ridge-Union Carbide people are apparently confident that the system can be satisfactorily scaled up. (4) Except for purging, this system is the least expensive alternative ($4-10 million) and the fastest to bring into operation (about 1 1/2 years). (5) The pressure and temperature at which the system operates are easily handled.

My main hesitation with recommending this system is that I have no first-hand experience with it. I would like to study it more closely and learn more about the details of its operation before making a final judgment.

B. Cryogenic Process System

The operating principle of this system is that Kr-85 may be separated from the other gases in the reactor building atmosphere by preferential condensation. The idea is that the boiling-point temperature (120°K) and the triple-point temperature (116°K) of Kr are higher than those of the nitrogen and oxygen in air. Thus if the atmosphere is exposed to a suitably cooled surface, the Kr-85 will be preferentially deposited by condensation. This allows for concentration of the radioactive gas.

This system is probably the second best alternative. These are some of the considerations: (1) The end product is isolated radioactive Kr-85 which could, for example, be contained in 57 gas cylinders each with 10^3 Ci. These could be safely handled and stored. (2) Unfortunately, this system is rather complex and somewhat more expensive ($10-15 million) than the Selective Absorption System. (3) Offsetting this is the advantage that there is an available system, which is about to be scrapped, which could be purchased and used at TMI. I take it that the system is functional and that its characteristics are well-known to the present owners. (4) The system is not quite a zero-release system; about 0.1% of the Kr-85 would be released.

C. Reactor Building Purge

The operating principle of this system is that the Kr-85 can be released through the plant vent stack over an extended period. For the suggested 60-day release period the average emission rate is 0.66 Ci/min. This is the least expensive and quickest of the alternatives but it has the greatest public dose of radioactivity. One can calculate from the usual meteorological considerations that the offsite public dose would be within design objectives.

The idea behind this system is the antithesis of the previous alternatives (A and B). Those previous alternatives ended up with maximum concentrations of isolated Kr-85 with minimal release of radioactivity. This system produces maximum dilution of the Kr-85 by releasing all of it to the atmosphere.

In my opinion this alternative is substantially less desirable than the Selective Absorption or Cryogenic Process Systems. Some of the considerations are these: (1) Meteorological conditions are notoriously hard to predict and values of the meteorological dispersion parameter (χ/Q) are notoriously uncertain. Once the Kr-85 goes out of the stack it is out of control. (2) As long as the Kr-85 is contained, the beta rays it emits will be absorbed by the container walls. It is only when the Kr-85 is in the open air that these beta rays can give doses to skin, lung epithelia, etc. (3) In my opinion some of the claimed advantages are largely semantic. Thus it is claimed (page 6-7 of NUREG-0662) that purging "eliminates the need for long term surveillance of Kr-85." I submit that the need for surveillance is still there after purging but our ability to carry it out is unfortunately eliminated. (4) Finally, I think that considerations of public sentiment and psychological stress point strongly against this alternative.

D. Charcoal Adsorption System, and

E. Gas Compression System

These systems can be discussed together since they share some common features. The systems both remove the Kr-85 from the reactor building atmosphere and the resultant radioactive gas is stored in large volume containers. Both methods are expensive and would require construction of large permanent structures on site, in which the Kr-85 is stored in dilute form.

In the Charcoal Adsorption System the Kr-85 is ultimately adsorbed on charcoal and stored in from 150 (refrigerated adsorber) to 450 (ambient adsorber) tanks each 60 feet high. In the Gas Compression System the Kr-85 is ultimately stored under pressure mixed in with 23,000,000 ft^3 (STP) of air. Since the Kr-85 alone would occupy only 1.4 ft^3 this seems like a needlessly inefficient procedure. The storage procedure for this alternative involves 28 miles of pipe of 36" outside diameter. In my opinion the problems of maintaining the large Kr-85 storage systems for long term, and free of leaks, as required by both of these alternatives are very serious.

Report submitted by,

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The amount of Kr-85 that is in the reactor building is 57,000 Ci. The particular difficulties involved with getting rid of Kr-85 are: (a) It has a long half-life (10.76 years) so that it decays slowly, (b) It is an inert gas so there are no easy chemical means for removing it, and (c) It is mixed in with the $2x10^6$ ft^3 of air in the reactor building.

Although the radioactivity due to the Kr-85 is large, the amount of gas is fortunately small. The actual amount of gas is only 1.7 moles, which at standard temperature and pressure (STP) conditions would occupy only 38 liters or 1.4 ft^3. Thus if the Kr-85 gas could be efficiently separated out it would all fit easily into one standard-sized gas cylinder at low pressure. As it is there are alternatives available which will contain the Kr-85 in a few gas cylinders at somewhat higher pressures. In my judgment the most natural solution to the problem is to take advantage of this; I recommend a method that in the end concentrates the gas in cylinders and, as far as possible, has zero release to the atmosphere. Fortunately two of the available alternatives do that, the Selective Absorption System and the Cryogenic Processing System.

Will long-term storage of Kr-85 be safe? If the Kr-85 gas is to be concentrated and stored we must provide for long-term safe storage. I believe that this is not difficult to do when one considers the nature of the emitted radioactivity. For Kr-85, 99.6% of the nuclear decays result in emission of a beta ray of energy 690 keV. Since this radiation consists of charged particles it will be stopped by the walls of any containing vessel. The other 0.4% of the nuclear decays emit mainly gamma rays of energy 514 keV. I have calculated that the intensity of this radiation is reduced by a factor of 10^6 by lead shielding 3.25" thick or by 27" of concrete. Thus the storage might simply consist of a few stainless-steel