United States Department of the Interior

GEOLOGICAL SURVEY
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DENVER, COLORADO 80225

IN REPLY REFER TO:

May 7, 1987

Docket No. 50-274
License No. R-113

Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Application for Temporary Amendment to License No. R-113.

Dear Sir:

It is requested that an amendment be issued to our facility license to permit the release of less than MPC-level radioactive water from the reactor tank to the ground water at the boundary of the Denver Federal Center. A suggested time limit for this amendment is one year in order to allow time to analyze options and implement a plan for a permanent solution. The background to the problem and an analysis of the pathway to ground water outside the Federal Center are presented below.

Background

The U.S. Geological Survey TRIGA Mark I reactor (GSTR) utilizes an in-ground reactor tank. The tank is fabricated from 1/4-inch thick 6061-T6 aluminum. The bottom of the tank is supported on a 3-foot thick concrete pad placed on concrete backfill. The outside of the tank was coated with tar and felt prior to installation. The sides are supported by 4 feet of concrete and a metal form surrounds the outside of the concrete. The tank is 8 feet in diameter, 25 feet deep, and contains approximately 9,000 gallons of water.

On March 17, 1987, holes were discovered in the aluminum tank. The reactor was shut down for repair of the tank and has remained shut down since. A plate was cut from the side of the tank near the top in order to allow detailed examination of one area of damage. This showed that the corrosion producing the holes originated on the back side of the tank where the tar coating was apparently poorly bonded and voids allowed water to come in contact with the tank. Beginning early in the operating history of the GSTR, tar was extruded from between the tank and the surrounding concrete shield as the tank expanded and contracted with changes in water temperature. This movement of tar (1 to 2 cubic feet were displaced) probably created the voids. Three possible sources for the water are:

1) intrusion of ground water (the evidence for this is circumstantial, but it must be presumed to have occurred),

2) overflow of tank water (this is known to have occurred at least twice), and

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3) condensation of water vapor when the tank was cooled to near 20° C.

A small sample of water was collected from one of the void areas for analysis. The chemical composition of this void water is very complex and has obviously been altered by contact with the tar, corrosion products of aluminum, and possibly concrete. It is impossible to identify a component of ground water in it. The tritium content does establish that it is two-thirds tank water and does contain constituents (Cu, Zn, Cl) at concentrations known to be corrosive to aluminum.

An epoxy, Concresive AEX1513 (Adhesives Engineering Company, San Carlos, CA) was selected to seal the penetrations. The advantages of this particular epoxy are:

1) it can be applied under water,

2) it bonds to aluminum, and

3) it is radiation resistant.

The epoxy was used to coat one side of 1/8-inch thick aluminum plates and these were then pressed over one or several holes.

Close observation of the tank will be instituted to verify the integrity of the patches and to watch for newly opened holes. We will make a thorough inspection of the tank surface each quarter using a strong light, binoculars, and a borescope.

Analysis

The Geological Survey TRIGA Reactor (GSTR) is located in Building 15 on the Denver Federal Center. The Federal Center is fenced and patrolled 24 hours per day. The public is admitted between the hours of 6 A.M. and 6 P.M. Monday through Friday.

The Federal Center is underlain by alluvial terrace deposits, composed of silt, clay, sand, and gravel, which in turn rest on the shale of the Denver Formation. The ground water level is about 20 feet below Building 15 and slopes gently to the east. The elevation of the surface of a small lake, Downing Reservoir, located 800 feet to the east of Building 15, limits the gradient to less than 20 feet per mile. Well drilling on the Federal Center is controlled by the General Services Administration, there are no pumped shallow wells, sampling wells are locked, and Downing Reservoir is surrounded by a locked fence. Thus, access by the public to the ground water is restricted.

For purposes of this analysis, the side boundary for unrestricted releases to the ground water is considered to be the boundary of the Federal Center. The nearest boundary to the east is approximately 1300 feet from the GSTR. The subsurface stratigraphy around Building 15 can be reconstructed from test borings made at the time of construction, from the hole dug for the GSTR tank, and from the recent drilling of the Building 15 sampling well 180 feet east of the reactor. At a depth of 30 feet, the Building 15 well penetrated 11 feet of water-containing sand above a hard clay layer which acts as a barrier to water penetrating to deeper aquifers. Water in the well rises to the general water table at a depth of 20 feet and when bailed, yields water at a recharge rate of about 4 gallons per minute. The concrete surrounding the GSTR tank rests on bedrock shales, and is surrounded by low permeability sandy clay as evidenced by the very small amounts of water which seeped into the construction hole, even though this hole penetrated 15 feet below the water table. This seepage was controlled by a small sump pump. These observations, when adjusted to the limit on the gradient of 20 feet per mile, are consistent with ground water flow rates of <0.1 foot per day at the well and <0.01 foot per day at the reactor tank. Thus, a very conservative upper limit to the ground water flow rate of 1 foot per day was adopted for this analysis.

A small fission-product release from a fuel element would be detected rapidly by the continuous air monitor (CAM), and the reactor would be shut down. The shutdown of the reactor would effectively halt the release of fission products due to the decrease in both fuel temperature and the internal pressure of the element. Thus, we will consider only those radionuclides found in the reactor tank water resulting from normal operation of the reactor. Table 1 shows the concentrations of radionuclides to be expected in the tank water following an 8-hour irradiation at 1 MW and decay times of 2 minutes and 10 days. These levels depend on the rate of removal by the ion exchanger as well as the rates of production and decay. The decay of the Gross Beta activity is consistent with the half-life for Na-24, thus all nuclides expected to be present at significant levels after 5 days should be identifiable by gamma-spectromety or tritium analysis. The long-lived radionuclides (except tritium) were measured by gamma-spectrometry in our reactor tank water following a 1-hour irradiation at 1MW. These values were used to compute the concentrations for the 8-hour irradiation and the two decay times. Levels for the short-lived nuclides were computed from gamma-measurements made on tank water from the Oregon State TRIGA Reactor, which has the same flow rate through the ion exchanger as ours. These measurements were made following an 8-hour irradiation at 1MW and were corrected back to a decay time of 2 minutes. The latter values were corrected to our tank capacity of 9,000 gallons. MPC levels are also listed.

The tank water should migrate very slowly along a tortuous path to the ground water because of:

1) the complex interconnection and small volume of the voids in the tar between the tank and the surrounding concrete,

2) the 4-foot thickness of the concrete, and

3) the steel form which surrounds the concrete.

Water levels observed before patching the tank indicate that the rate of outflow of tank water was less than 1 liter per hour. Similar observations after patching the tank limit the rate of outflow to less than 0.2 liters per hour.

After reaching the ground water, radionuclides in the tank water will be assumed to migrate at the same rate as the ground water, 1 foot per day, although it must be recognized that the migration of most of these will be retarded substantially due to ion exchange on the clay. At this rate, 10 days would be required to migrate 10 feet and more than 3 years to reach the boundary of the Federal Center, 1300 feet away. In addition, no dilution factor has been taken.

It is evident that after 10 days, or less than 10 feet of migration, all concentrations are well below MPC. The only detectable radionuclide reaching the boundary of the Federal Center will be tritium, and it will be present at levels well below MPC.

Conclusion

Based on the information stated above, we have concluded that the proposed change does not involve a significant hazard, and the health and safety of the public will not be endangered.

Sincerely,

Hugh T. Millard, Jr.
Reactor Administrator

cc: Document Control Desk
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Reactor Operations Committee

Table 1. Radionuclide Concentrations in GSTR Tank Water pCi/liter. (Irradiation Time = 8 hours)

	Decay Time	
	5 hours	5 days
Gross Alpha	1100	0
Gross Beta	10000	100

	Half-Life	Decay Time 2 minute	10 days	MPC
Short-lived nuclides:				
Ar-41	1.8 hours	1.2 E+6	0.	no value for water
Mn-56	2.6 hours	6. E+4	0.	100000.
Na-24	15. hours	8. E+4	1.	200000.
Long-lived nuclides:				
Mn-54	310 days	<30.	<30.	100000.
Co-60	5.3 years	<50.	<50.	50000.
Tritium	12. years	75000.	75000.	3.E+6
Cs-137	30. years	<40.	<40.	20000.