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ESTIMATE OF LEGACY TRITIUM IN BUILDING 232-H TRITIUM FACILITY, SAVANNAH RIVER SITE

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ESTIMATE OF LEGACY TRITIUM IN BUILDING 232-H TRITIUM FACILITY, SAVANNAH RIVER SITE

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ESTIMATE OF LEGACY TRITIUM IN BUILDING 232-H TRITIUM FACILITY, SAVANNAH RIVER SITE

Elliot A. Clark

SUMMARY

The amount of legacy tritium existing in the tritium processing system in Building 232-H at the Savannah River Site after this building is deactivated is estimated to be on the order of 37 grams of T_2, or about 350,000 curies. This estimate was calculated by creating an inventory of components (including equipment, pipe, tanks, and other facilities) that will remain in 232-H after it is deactivated. Estimates of tritium in many components were taken from existing estimates used for waste disposal. For pipe and tanks, the tritium content was calculated using the results of previous measurements of tritium in samples removed from a used container were scaled to the surface area exposed to the process gas. It is shown that over 80% of the legacy tritium will reside in polymers, used for gaskets and in valves. It is believed that the tritium in polymers will be released if exposed to excessive heating or a fire.

INTRODUCTION

Building 232-H at the Savannah River Site has processed tritium since 1958. Major operations in this building include tritium extraction from irradiated targets, gas purification, isotope separation, water vapor processing, and loading and unloading shipping containers. The Materials Test Facility (MTF) is located in 232-H, where reservoir life storage and other tritium-related research and surveillance programs occur. Other facilities located in 232-H include a Function Test Facility (FTF) and portions of Reservoir Surveillance Operations (RSO).

Current plans are to deactivate Building 232-H by 2006. (The Tritium Facility Modernization and Consolidation project is reproducing those process functions currently conducted in 232-H in other facilities. The CLWR-Tritium Extraction Facility project will enable tritium extraction from the new Commercial Light Water Reactor targets.) The deactivated building will have no power or utilities, and can be described as being “cold, dark, and dry”. All connections with ongoing buildings will be separated and capped. The processing system will be flushed with argon and remain closed. Many process beds (zeolite, and uranium beds, for example) will be removed and the connections capped. An externally controlled exhaust fan will maintain a minimal vacuum, and airflow will be maintained in the process hoods. Tritium emissions from the stack will continue to be monitored. Most combustible materials will be removed, including furniture and carpets since no fire detection or suppression systems will be maintained.

It is well known that tritium gas permeates into all components it contacts to some degree. Tritium molecules dissociate on metal surfaces, such as stainless steel, and diffuse as single atoms into the near surface region. Tritium molecules dissolve in polymers, and diffuse throughout the polymer. Tritium can isotopically exchange with hydrogen atoms that are a major constituent of most polymers, and become part of the molecular structure of the polymer. Because of this permeation, components in tritium processing systems that are wetted by tritium will take up significant amounts of it. The amount of tritium permeating into a given component depends significantly on the material, temperature, tritium partial pressure, and the condition of the surface of the material. For example, metal oxides can absorb tritium as can any organic or oil film on surfaces.

This report describes an estimate of how much tritium will be held up in those parts of the 232-H process that will remain in the building after deactivation. The anticipated state of this tritium is also discussed. This information will be used to assess the radiological status of the deactivated facility.

CHARACTERIZATION DESCRIPTION

This characterization consists of inventorying the components and systems that will remain in the deactivated 232-H, and compiling estimates for the tritium content of each (Table I below). Tritium characterizations have already been determined for many components such as pumps, valves, gaskets, and so on. These characterizations are used for waste disposal, and are assembled in a database maintained by Defense Programs, the "Curie Content" database in the Tritium Technical Files area of the Tritium Databases server.

An important source of tritium not determined by waste characterization data is the amount of tritium residing on and near the interior surfaces of process pipes and tanks. Several years ago, samples cut from an LP-50 product container (used to transport tritium gas) were removed so the total residual tritium existing in the stainless steel wall could be measured (to enable retired containers to be returned to SRS) [1]. The conditions of exposure to the walls of the LP-50 are very similar to that in the fixed processing system in Building 232-H. Specifically, the temperature (ambient), tritium partial pressure (vacuum up to 2 atmosphere), time (39 years) and material (Type 304L stainless steel) are virtually identical. Because of the similarity of exposure conditions, results from the LP-50 study can be used for a tritium characterization of the 232-H process pipes and tanks. The LP-50 study provides an estimate of the residual tritium concentration per unit area. The amount of tritium able to be exchanged with humidity in air was estimated by monitoring tritium offgassing (using an ion chamber) and performing aqueous leaching experiments. The amount of tritium dissolved in the bulk was estimated by dissolving the stainless steel in a nitric acid/hydrochloric acid mixture. The tritium that leached into water and that which dissolved in aqua regia was measured using multiple dilutions and liquid scintillation counting.

The other factor in estimating the tritium burden in pipes and tanks in this way requires estimating the size of the system as measured by the total internal surface area of the pipes and tanks exposed to the process gas. Standard practice in tritium systems is to measure the process volume of each and every section of the process (for example, the volume of pipe between all valves and other components). The total surface area (internal) of the exposed pipe and tanks can be estimated using the measured volumes of each section of pipe and each tank, along with typical pipe diameter and tank dimensions [2] (Table II below). The final characterization of residual tritium in pipes and tanks consists of multiplying the specific residual tritium concentration by the estimated internal surface area.

Two cryogenic stills ("cryostills") separated hydrogen isotopes in 232-H. These consisted of a long tube filled with a type of stainless steel packing, coiled into small spring-like pieces. A "re-boiler" was at the bottom of the pack region, and a condenser was at the top. These stills operated at nearly liquid helium temperature. To conservatively estimate the residual tritium in each still, the same residual tritium per unit surface area used for tanks and pipes was employed. The surface area of the packing accounts for most of the surface area in these stills. The geometry of the packing was inferred from a photograph of the packing and measurements at a web site (http://www.lab-glass.com/html/nf/DSTA-LG-6730.html). An engineering drawing of one of the cryostills indicates that about 15 pounds of packing were used. The total surface area was calculated using the density of stainless steel and the geometry of the packing (Table III.). The estimated residual tritium on the packing was much larger than that estimated for the interior of each still, since the surface area of the packing is much greater than the interior surface of the still container. (The packing is employed specifically to increase surface area in distillation columns.)

In addition to the cryogenic stills, four thermal diffusion columns were used to separate hydrogen isotopes. They consisted of a long tube with a platinum wire in the middle. The wire was heated by Ohmic heating (passing an electric current). Since different isotopes have slightly different thermal diffusivities, there is a gradual separation from top to bottom. The main tube of the column that was exposed to tritium was cooled on the outside by water, so the temperature of the exposed surface was approximately ambient temperature. Thus, the legacy tritium is estimated to be the same amount per unit area as in the LP-50 case, and the total tritium is the internal wall surface area times the LP-50 (Table IV below).

CHARACTERIZATION RESULTS AND STATE OF LEGACY TRITIUM

Table I contains all of the contributions and totals the estimated quantity of tritium. The sum is about 350,000 Ci, or about 37 grams of T_2. Also indicated in Table I is the relative amount of this that resides in polymers, 82%. The vast majority of tritium resides in Type E flange gaskets, made of Buna-N, and in automatic and manual valves. These type of valves are considered to be polymers because they have polymer parts that absorb the tritium and account for the curie content retained by these valves. It is quite likely that this tritium will be released if these parts directly contact a fire. It is also likely that these parts will degrade with time, and the remaining system is expected to gradually leak over time. There are no plans to mitigate these leaks.

ADDITIONAL TRITIUM NOT INCLUDED IN CHARACTERIZATION

There is a section of pipe, about 10 feet long, that contains a powder containing FeO, $FeCl_3$, iron oxide/hydroxide, Hg_2Cl_2, and Hg_2Cl [3]. The tritium content of this so-called "stripper dust" is unknown. Radiography indicates that the pipe containing this powder has remained sound over at least ten years. Because of the hazards associated with sampling this stripper dust, no estimate for the tritium content is available and so none is included in the characterization described in this report.

In addition, there are some locations that contain an undetermined amount of oil. It is anticipated that this oil contains significant quantities of tritium. The amount of oil and its activity are unknown and therefore are not included in this characterization.

This characterization does not include the so-called "Line III" facility, which was characterized previously.

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Component	Material	Number	Tritium Content (Ci)	Total Curies	Estimate Level	Notes
Process Equipment to Remain in Building 232-H After Deactivation						
CA Bed (a.k.a. Catalyst Bed??)	SS	3	1000	3000	2	
TCAP	SS	1	0	0	Process knowledge	
Thermal Diffusion Columns	SS	4	76	304	(see separate calculation)	
500 CryoStill	SS	1	633	633	(see separate calculation)	
100 Cryostill	SS	1	609	609	(see separate calculation)	
Hydride Pumps (Pd/K)	SS	3	50	150		Assumes this is "Pd trap"- Verify. Also- only burden in SS container, not residual in Pd
Gold Traps (233-H transfer)	SS	5	10	50	2	
DeOxy Bed	SS	1	1000	1000	2	Estimate based on similar components
Pumps to Remain in Building 232-H After Deactivation						
Metal Bellows (dry) (includes 1 for FTF)	SS	47	68	3196	1	Value for entire pump, including both bellows assemblies, both reed valve assemblies and inter-head piping
Normatex (scroll) (includes 1 for FTF)	SS	13	27	351	1	Value for 233-H same for 232-H
Sprengle (Hg displacement)	SS	6	10	60	2	Estimate based on similar components
PPI (oil pump, with diaphragm)	SS	4	35	140	1	
XME-3 (Hg diffusion, smaller version of XME-3)	SS	3	130	390	1	
Stokes (Turbopump)	SS	1	0	0	Process knowledge	
CVC (Hg diffusion)	SS	2	10	20	1	
MHg 900 (Hg diffusion)	SS	2	50	100	2	Estimate based on similar components
Process Valves						
Manual Valves , 2" and below	Polymer	624	76	47424	1	MTF, FTF NOT included.
Automatic Valves (includes 6 from FTF)	Polymer	1091	76	82916	1	MTF NOT included.
Total Equipment, Pumps, Process Valves				**140,343 Ci** **14.6 g T2**		
Additional Components or General Items Not Included in Above						
Welch pump 1402	SS	8	46	368	1	
Welch pump 1399	SS	7	10	70	1	
Kinney pump KTC-60	SS	2	151	302	1	
Roots pumps XA-22	SS	69	11	759	1	
Balzer turbo pump (FTF)	SS	1	11	11	2	Estimate based on similar components
Balzer vane pump (FTF)	SS	1	50	50	2	Estimate based on similar components
D/P Cell	SS	2	38	76	1	
JMI Diffuser	SS	5	48	240	1	
Moisture sensor M1 & M2	SS	2	12	24	1	
Edwards Pump E2M18 double stage	SS	1	29	29	1	
Edwards Pump E2M	SS	3	35	105	1	
TPU 330 Turbopump	SS	1	11	11	1	
Oil Mist Eliminator KTC-21	SS	3	17	51	1	
Buna-N gasket for Type E flange	Polymer	5000	32	160000	1	
Rupture disks- CalMec	SS	45	0.085	3.825	1	
Rupture disk assembly- CalMec	SS	45	0.2	9	1	
Met Bel pump O-ring	Polymer	46	5.3	243.8	1	
TCVG tubes	SS	102	0.1	10.2	1	
Valve Parts (general)	SS	7	75	525	1	
Pressure transducer	SS	207	0.1	20.7	1	
Total Additional, General Items				**162,909 Ci** **16.9 g T2**		
Grand Total- Components and Pipe/Tanks (includes separate spreadsheet)				**352,867 Ci** **36.7 g T2**		

Tritium in Polymers	290,584 Ci **30.2 g T2**	
	82%	of tritium is in polymer parts

Table I. Listing of Components and Tritium Characterization for Building 232-H. Total tritium content is found by multiplying the number of each component by its estimated tritium content. The Estimate Level for each component describes the how the estimate was made: Level 0: Testing or Verified Calculation, Level 1: Calculation (E7), Level 2: Engineering Judgement. Material: SS is stainless steel (3XX series austenitic). Does NOT include Line III (Extraction furnaces etc.).

Wermer Paper	
Exchangeable	35 Ci
Dissolution	27 Ci
LP-50 Internal Surface Area	1,350 in^2
Specific Exchangeable Activity	.026 Ci/in^2
Specific Dissolved Activity	.02 Ci/in^2

Materials Test Facility Internal Surface Area							
Tanks (LP-50)	2		1350	in^2	Total MTF Tanks	2700	in^2
Tubing	478	cc	29	in^3			
	0.25	in OD					
(excludes calibrated volumes							
that will be taken out of 232)	0.035	in wall	1147	inch long		649	in^2
	0.18	in ID					
(All metal valves in MTF)					Total MTF surface area >>	3,349	in^2

Manifold	Volume (cc)
center	194
B	152
A	92
	16
Test port	24
Total	478

MTF Tanks & Pipes Exchangeable (Ci)	Dissolved (Ci)	Total FTF
87	67	154 Ci

Function Test Facility Internal Surface Area					
Piping		Length (feet)	ID (inch)	Info coming from Brett Bell per phone conv 1 Aug	
	1 inch pipe	36	1.049	Assume Schd 40S	1424
	1/2 inch pipe	30	0.622	Assume Schd 40S	703
	1/2 inch tube	15	0.430	Assume 0.035 wall	243
	3/8 inch tube	55	0.305	Assume 0.035 wall	632
				Total pipe & tube internal area:	3003

Tanks		Volume (liter)	Diameter (inch)	Length (inch)	Area (in^2)
	2	100	18	22	1753
	1	100	12	28	1282
	1	230	24	22	2564
	1	15	8	22	653
	1	30	12	18	905
Bell jar		800	36	48	7464
			Total FTF surface area >>		17,624 in^2

FTF Tanks & Pipes Exchangeable (Ci)	Dissolved (Ci)	Total
457	352	809 Ci

232-H Lines I & II Surface Area and Total Surface Area of Pipe & Tanks in 232-H	Surface Area (in^2)	Exchangeable (Ci)	Dissolved (Ci)		
Line I Vessels	305554	7922	6111	McGee/Horton	
Line II Vessels	222877	5778	4458	McGee/Horton	
Line I Piping	215827	5596	4317	McGee/Horton	
Line II Piping	315106	8169	6302	McGee/Horton	
Materials Test Facility	3349	87	67	See sheet above	
Function Test Facility	17624	457	352	See sheet above	**Pipe/Tank Total**
Total		28009	21607		**49,615 Ci**
		2.91	2.25		**5.2 g T2**

Table II. LP-50 tritium data, MTF, FTF, and Total Line I and Line II 232-H Internal Surface Area and Tritium Estimate from LP-50 data. Internal surface area estimated for each facility knowing system volumes and typical dimensions for pipes and tanks.

HeliPak Packing	15	lbs.	per drawing for 100 still	
				flattened coils dimension in
(both stills)	0.09	0.175	0.175	inches, per picture- size C
	10	turns per coil, from picture		
	0.0175	diameter (inch)		
	0.29	lb/in^3	density of Type 316 stainless	
	6.97532E-05	lb/in of length		
	215044	inches of coil length in bed		
	11823	in^2 area of coils		
		Exchangeable (Ci)	Dissolved (Ci)	Total
		307	236	543 Ci

500 Cryostill			Surface Area (in^2)			
Condenser	8	inch diameter	302			
	12	inch long				
	8	inch diameter	452			
	18	inch long				
	10	inch diameter	188			
	6	inch long				
Pack region	2	inch diameter	823			
	131	inch long				
Reboiler	6	inch diameter	188			
	10	inch diameter		Exchangeable (Ci)	Dissolved (Ci)	Total in container
Total in container			1,954 in^2	51	39	90 Ci
500 Cryostill total	**633 Ci**	(includes packing)				

100 Cryostill			Surface area (in^2)			
Condenser	6	inch diameter	226			
	12	inch long				
Pack region	2	inch diameter	779			
	124	inch long				
Reboiler	8.63	inch diameter	434			
	16	inch long		Exchangeable (Ci)	Dissolved (Ci)	Total in container
Total in container			1,439 in^2	37	29	66 Ci
100 Cryostill total	**609 Ci**	(includes packing)				

Table III. Estimate of Tritium in Cryogenic Distillation Columns (500- and 100- Cryostills).

Thermal Diffusion Column		
Diameter	1.22	inch
Length	432	inch
Surface area	1,657 in^2	
Exchangeable (Ci)	Dissolved (Ci)	Total in 1 Diffusion Column
43	33	76 Ci

Table IV. Estimate of Tritium in one Thermal Diffusion Column. Interior surface area of column calculated.