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TITLE DISPERSION AND REMOVAL OF TRITIUM RELEASED INTO THE MAIN CELL OF TSTA

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DISPERSION AND REMOVAL OF TRITIUM RELEASED INTO THE MAIN CELL OF TSTA

Abstract

Approximately 145 millicuries (about 0.06 cm^3) of tritium in DT form were released into the main cell of the Tritium Systems Test Assembly at Los Alamos National Laboratory. At equilibrium with the cell isolated, this amount resulted in concentrations of about 50 microcuries per cubic meter throughout the 2900 m^3 of the cell volume. Tritium was held in the cell for 29 minutes before normal ventilation was restored and the tritium was released through the facility's 30-m stack. The dispersion, confinement, removal, and decontamination times associated with this release are discussed in this paper.

Introduction

Objectives of the Tritium Systems Test Assembly include demonstrating the fuel processing cycle for fusion power reactors, developing and testing environmental and personnel protective systems, and investigating the system response to abnormal conditions.

A release of 145 millicuries of tritium into the main cell of TSTA was used to gain information in pursuit of these objectives. The tritium was held in the cell for 29 minutes with the cell isolated (normal room ventilation halted). Tritium levels in the cell equilibrated at 50 microcuries per cubic meter in the 2900 m^3 cell. After 29 minutes, normal ventilation was restored. Tritium was released out the facility's 30-m stack by normal ventilation while the declining tritium levels in the cell were observed on eight room monitors located throughout the facility.

Resultant surface contamination in the cell was monitored for several days, until surface contamination returned to the uncontaminated condition that existed before the release. Possible tritium leakage around penetrations from the room during the hold period was monitored with portable tritium monitors. No signs of leakage were found.

The results are of importance for understanding the dispersion, removal, and residual effects of tritium in a fusion test cell. The results are of comparable importance to the processing technology developments and demonstrations also furnished to the fusion community by the TSTA project.

The Facility, Equipment, and Tritium Monitors

Summary descriptions of the TSTA facility and its subsystems can be found in the literature [1,2]. A photograph and room layout of the facility are shown in Figures 1 and 2. These figures describe the tritium handling facility and [illegible] as necessary for the purposes of this paper. Included in Figure 2 are the locations of the eight room tritium monitors permanently installed at TSTA. These eight monitors (six in the main cell and two in adjacent [illegible] on the same ventilation system) were used to trace the release and spread of tritium in the facility, its planned confinement for a period of time, and its eventual removal through normal room ventilation. The high [illegible] monitors with minimum sensitivity of [illegible] are [illegible] shown.

Room tritium monitors

The eight room monitors have been described in the literature [3]. They are commercial instruments covering the range from 1 microcurie/m^3 to 10 Ci/m^3 on two, 4-decade logarithmic scales with one decade overlap. Each monitor has three alarm set points to provide warnings of tritium releases both locally and through the central control computer with which the monitors are interfaced.

Each monitor samples room air at several points. This is done through the use of sampling lines, usually with multiple branches, to locations in the vicinity of the instrument. This procedure reduces monitor sensitivity, but greatly increases the spatial coverage of the monitor. The general question of tritium dispersion in room air and its relationship to monitor location has been studied previously [4].

Computer-controlled safety systems--room monitors, alarms, and room ventilation

The TSTA is a computer controlled facility designed with special attention to the use of the computer to maintain safe conditions in off-normal situations, including failure of the computer itself. In the tests reported here, the Master Data Acquisition and Control System (MDAC)--the central control computer system--served in various functions to maintain safety. All room tritium monitors (like all facility instruments) report to the MDAC. MDAC sounds room alarms as appropriate, including when tritium at hazardous levels is detected in the room. The alarm condition is announced by a facility operator over the PA system.

Normal room ventilation consists of air inflow through ducting and vents located along the west wall of the main cell (adjacent to rooms #5507-5511). The room air exhaust is through parallel ducting and vents located in the middle of the ceiling of the main cell. When room ventilation is halted, these exhaust vents are shut by isolation valves.

At the high alarm level, an evacuation alarm is automatically sounded and MDAC shuts isolation valves and halts the normal room ventilation out the facility's 40-meter stack to prevent the automatic stacking of unacceptable amounts of tritium. In this test, valves were shut and room ventilation was halted by auxiliary actions through the computer because the tritium concentrations in the room were below those necessary to produce automatic isolation of the test cell. The isolation of the test cell lasted 29 minutes, which gave sufficient time to reach equilibrium concentrations of tritium in the room and to monitor for tritium leakage from the room around doorways in air locks. After 29 minutes, normal room ventilation was restored through manual commands to MDAC.

The Release of Tritium in the Main Cell

At 3:44:1 (time = 24 pm) in the afternoon of November 7, 1988, [illegible] curies of tritium were released into the main test cell of TSTA [illegible] the main test cell of the test preparation system (near Tritium Monitor TM3). The release was made at the glove box window located on the mezzanine. This glove box is partly primarily because in normal operation this glove box [illegible] the main part of the total tritium inventory of TSTA. Normally [illegible] of the TSTA [illegible] the cryopumps located in the [illegible] of the test preparation system (TPS).

contains the major part of the total tritium inventory of TSTA. Normally 80-100 grams of the TSTA total of 130 grams reside in the cryogenic distillation column of the Isotope Separation System (ISS).

The release was in elemental molecular form of DT, the usual form of tritium contained in the TSTA process piping. However, any release will be accompanied by the release of some tritium in the oxide form (DTO). The fraction in the oxide form will increase slowly with time as the tritium combines with room air under the action of catalytic influences such as metal surfaces and self-radiolysis.

The highest momentary tritium concentration recorded by the room monitors was 520 microcuries per cubic meter recorded by TM-RM3 immediately after the release. As a point of reference, the facility's written guides define the permissible safe working time in this concentration, if the tritium were all in the oxide form, at about 10 minutes. The corresponding working time in the steady-state concentration reached in the room (50 microcuries per cubic meter) is about 100 minutes.

Room ventilation was halted by auxiliary MDAC action at 14:46:24, 1 minute and 44 seconds after the room release.

The Dispersion of Tritium Through the Cell

With room ventilation halted, tritium dispersed through the cell (and into two side rooms designed for handling tritium) as shown in figure 4 and in tables 1 and 2. The tritium concentrations rose most slowly at TM-RM2, in the pit area underneath the mezzanine where the release occurred, and in the XCS laboratory, through a doorway in the farthest corner of the facility from the release. It took about 10 minutes after room isolation to reach essentially steady state.

During the 29 minute holding period with room ventilation halted, a portable tritium monitor was used to check for tritium leakage around the inner doors of air locks leading to the main cell. An Overhoff Model 394C tritium monitor was used that had a sensitivity of 2-3 microcuries per cubic meter. With this instrument and for the duration of the test, no tritium was detected leaking around the inner doors to the cell.

After tritium in the main cell became uniform in concentration, a slight decrease in levels was observed. This is believed to be from slight adsorption on surfaces of the cell or diffusion toward the ceiling away from monitors, since no leakage at cell boundaries was observed.

The Removal of Tritium from the Cell

Normal ventilation was restarted at [illegible]. This restarted the flow of ventilation air up the stack.

The removal of tritium from the main cell is shown in figures 5 and 6. These figures each show the decline of tritium in the room. It is noteworthy that tritium was removed from the cell in general faster than the "ideal" removal rate assuming perfect mixing in the cell. This is true at essentially all locations in the cell. There is no clear understanding of this favorable result.

The room tritium monitors generally returned within 30 minutes to their background settings that were reached before the tritium release took place. These are in the neighborhood of five microcuries/m^3, rather than zero, because the monitors are designed to have a slight indication at all times so that a failed (zero-reading) monitor will stand out.

To a first approximation, tritium was removed from the cell within a half hour. However, careful tatistical analysis of the monitor readings indicated that slightly elevated readings persisted for several days. These results are shown in figures 7 and 8 for each monitor. The figures show the "noise" on each monitor reading (indicated by the vertical line shown for each day) and the least squares fit of the readings for each day. Clearly the readings are somewhat elevated 24 hours following the release. This elevation is no longer apparent by the third day following the release.

Analysis of Residual Surface Contamination

The building surfaces at TSTA are coated with "Plasite," an oil-base epoxy paint. Surfaces at TSTA are routinely "swiped" for removable surface contamination, analyzed by a liquid scintillation counter, and reported in units of disintegrations per minute per 100 cm^2 of surface swiped (dpm/100 cm^2). A surface reading with a reading of less than 1000 dpm/100 cm^2 is considered uncontaminated. Areas having surfaces with readings above 20,000 dpm/100 cm^2 require special posting and contamination control [5].

The readings reported at TSTA before the release and for one month following the release are given in table 3 below. From the results shown, no long-lasting contamination of surfaces resulting from this release was detected. No special decontamination efforts were made other than the usual ones of washing down warm spots noted during routine surface monitoring.

Summary and Conclusion

A small amount (2.5 millicuries) of tritium was released into the main cell of a representative fusion tritium facility. The dispersion of tritium through the cell with room ventilation halted was monitored with eight room tritium monitors. A portable monitor was used to check for leakage from the cell. After 30 minutes, normal room ventilation was restarted and the removal of tritium in the cell monitored. Analyses were made for residual contamination in room air and on surfaces.

The principal conclusions of the test are:

1. Tritium became distributed uniformly in the cell within 10 minutes.

2. No tritium was detected leaking out around the inner doors to the cell.

3. With ventilation, tritium was removed from the cell faster than predicted by idealized calculations assuming perfect mixing in the cell.

4. No residual air contamination remained three days after the release. No residual removable surface contamination remained one month after the release.

The results of this test may be dependent on conditions of this test and the physical configuration of the TSTA facility. However, the tests were made in a prototype facility using only the special precautions that are designed into and are always a part of such a facility. The results constitute an important part of the database on normal and off-normal operations provided from the TSTA project.

References

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3. R. A. Jalbert, "Tritium monitoring at the Tritium Systems Test Assembly," Proceedings of the 6th International Congress of the International Radiation Protection Association, Vol. II, 1984, pp. 920-23.

4. M. T. Enderlee and E. A. Bemis, "A study of the diffusion and mixing of tritium gas in air," Los Alamos National Laboratory Report, LA-7671, TID-4500, 1979.

5. D. Ronquillo, editor, "Health and Safety Manual," Los Alamos National Laboratory, AP. 100, August 1988.

Table 1 The Course of Events on 11/7/88

TIME	ELAPSED TIME	EVENTS
14:44:23	-	All monitors show normal values
14:44:xx	-	Tritium release near ISS (TM-RM3) in the main cell
14:44:40	-0-	Mid alarm at the mezzanine, ISS (TM-RM3) (Tritium concentration > 100 micro Ci/m^3)
14:45:18	0'38"	Low alarm at the mezzanine above the FCU (TM-RM1) (Tritium concentration > than 20 micro Ci/m^3)
14:46:02	1'22"	Low alarm in the south of the VAC (TM-RM5)
14:46:24	1'44"	Isolation of the main cell from the atmosphere
14:46:35	1'55"	Low alarm at the north of the VAC (TM-RM4)
14:49:18	4'38"	Low alarm around the glovebox of the SWD (TM-RM6)
14:49:30	4'50"	Low alarm in the GAN room (TM-GAN)
14:51:00	6'20"	Low alarm at the pit of the FCU (TM-RM2)
14:53:18	8'38"	Low alarm in the XCS room (TM-XCS)
15:13:45	28'55"	Tritium removal from the main cell begins using the room ventilation

Table 2 Readouts of the Tritium Room Monitors

(unit: micro Ci/m^3)

11/07/88	Elapsed Time	RM 1	RM 2	RM 3	RM 4	RM5	RM 6	GAN	XCS
14:44:23		3.2	5.0	2.2	4.0	3.8	3.6	8.1	5.2
14:44:40	-0-			------Tritium Release------					
14:45:24	0'44"	49.3	4.5	521.8	10.5	10.7	4.4	7.5	3.5
14:46:24	1'44"	52.5	7.8	107.2	32.9	43.4	4.5	7.5	4.0
14:47:24	2'44"	50.4	14.2	47.3	31.8	28.7	28.8	11.4	3.6
14:48:24	3'44"	52.5	13.2	57.2	35.5	23.4	15.0	15.9	3.6
14:49:25	4'45"	58.2	17.4	54.3	40.7	34.9	30.4	22.3	4.5
14:50:24	5'44"	59.6	19.5	65.7	43.9	33.9	33.3	27.4	6.7
14:51:27	6'47"	65.7	21.6	63.5	52.2	38.5	41.0	32.2	14.0
14:52:26	7'45"	66.1	24.8	63.5	56.2	40.3	49.5	38.9	24.8
14:53:27	8'47"	65.3	26.3	58.5	59.6	49.3	48.7	39.8	28.0
14:54:26	9'46"	67.6	30.9	57.5	58.9	53.4	46.8	41.0	31.4
14:55:28	10'48"	65.3	36.1	54.3	60.3	53.7	44.9	40.0	32.9
14:56:27	11'47"	64.6	38.9	52.8	58.5	58.5	41.0	41.4	35.7
14:57:29	12'49"	62.0	43.4	57.2	56.9	61.3	39.8	42.4	34.7
14:58:29	13'49"	61.3	46.0	59.2	53.7	63.1	38.7	43.2	35.1
14:59:29	14'49"	60.3	47.6	55.3	51.0	64.2	37.6	42.7	35.1
15:00:31	15'51"	58.9	48.4	58.2	49.8	62.7	37.6	43.2	34.5
15:01:30	16'50"	59.9	48.1	55.6	47.9	61.7	37.6	41.9	35.9
15:02:32	17'57"	56.6	47.0	57.2	47.6	63.8	37.6	41.4	36.3
15:03:32	18'52"	58.2	47.3	55.9	47.0	61.0	36.9	43.2	38.5
15:04:33	19'53"	57.2	47.3	55.9	45.7	62.7	37.8	45.4	41.4
15:05:34	20'54"	57.2	46.5	55.6	46.5	62.0	37.4	45.2	37.2
15:06:34	21'54"	55.6	46.5	56.2	46.2	61.7	37.6	42.4	36.1
15:07:35	22'55"	56.9	45.4	55.6	46.5	60.6	36.7	41.7	35.5
15:08:35	23'55"	55.0	43.9	55.0	45.4	62.0	36.9	42.7	38.9
15:09:34	24'54"	54.3	44.9	54.6	45.2	61.7	39.4	41.7	37.4
15:10:35	25'55"	55.6	44.4	53.1	45.2	59.2	36.9	43.2	36.5
15:11:35	26'55"	56.2	43.9	54.0	44.4	58.5	36.5	44.4	36.1
15:12:36	27'55"	54.0	43.4	52.8	45.7	59.2	36.7	42.4	37.2
15:13:35	28'55"	53.7	44.7	53.4	44.4	59.2	37.6	42.4	37.4

Table 3 Results of the Swipe Analysis
(Units:dpm/100cm^2)

Location	11/02/88	+	11/09/88	11/22/88	11/30/88	12/07/88
GB-LIO	173	+	686	152	2105	736
GB-INV	148	+	655	320	827	223
GR-TPU1,2	128	+	384	626	121	504
GB-TPU3	3703	+	4443	33829	1440	580
GB-UTB	10921	+	6002	30636	13909	10400
TWT-TANK	222	+	478	659	386	637
GB-ISS	1019	+	4423	2123	5910	669
GB-ISS-GAN	322	+	2138	424	688	4024
GB-XCS	123	+	3170	65	445	263
GB-GAN	510	+	3156	263	1548	1486
GB-SWD	1108	+	2748	501	1364	1553
FLOOR-LIO	8451	+	1827	1633	309	465
FLOOR-TPU1,2	466	+	407	670	259	397
FLOOR-TPU3	1899	+	3196	7476	2308	952
FLOOR-UTB	5161	+	24027	33466	36668	1689
FLR-TWT-PIT	2771	+	3137	2086	91474	670
FLR-ISS-MEZZ	2072	+	138639	27750	2577	957
FLR-TWT-MEZZ	654	+	1607	2407	1685	1060
FLOOR-XCS	334	+	781	618	2681	601
FLOOR-GAN	959	+	969	1794	14965	1610
FLOOR-SWD	2704	+	1632302	13341	4002	2232
BKG	NSA	+	112	NSA	NSA	97

+ 11/7/88 Tritium Release

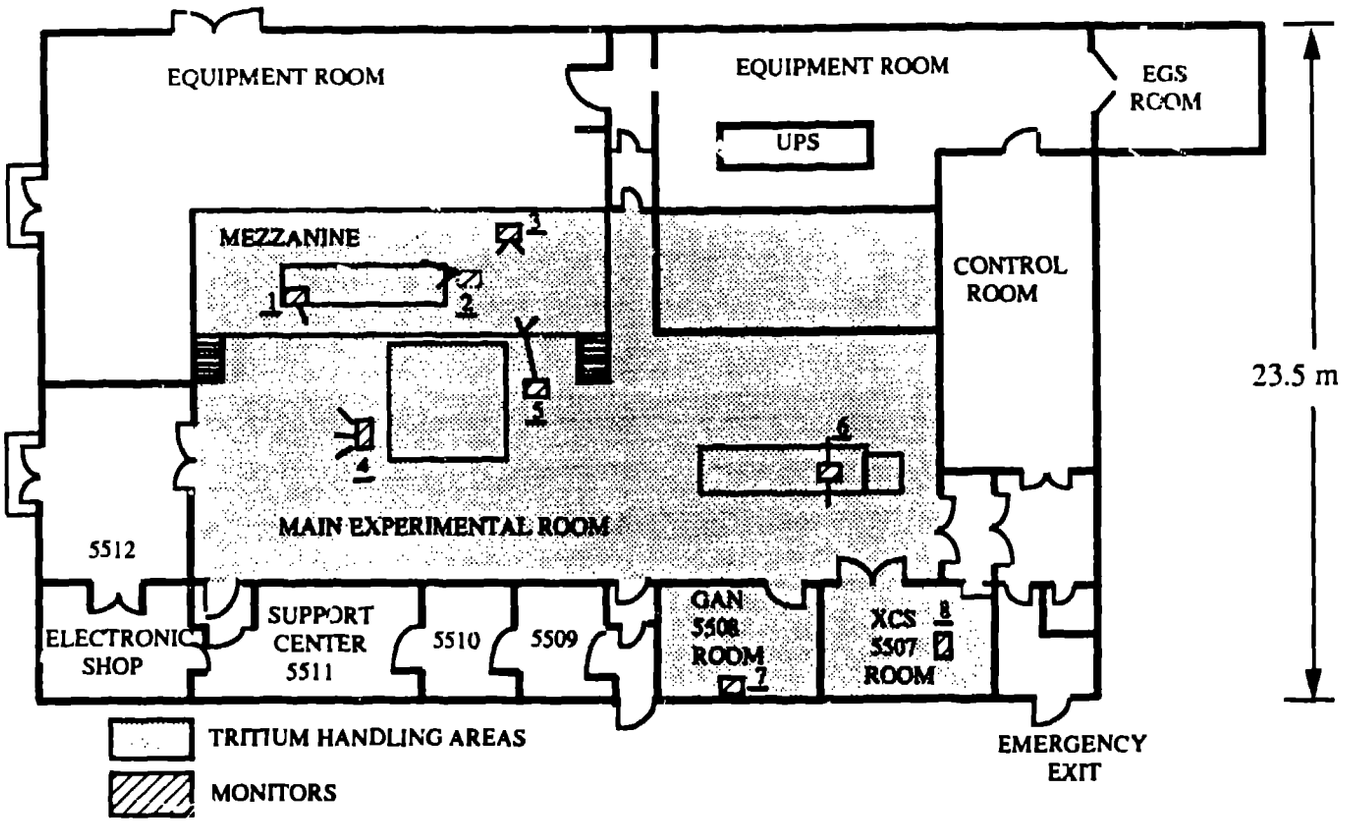

Fig. 2. Location of Room Tritium Monitors at TSTA