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Tritium contamination experience in an operational D-T fusion reactor

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During December 1993, the Tokamak Fusion Test Reactor (TFTR) injected a mixture of deuterium and tritium in the TFTR vacuum vessel for the purpose of creating D-T plasmas. The tritium used in these D-T plasmas was stored, delivered and processed in the TFTR tritium facility that includes the tritium vault, waste handling area, clean-up area, and gas holding tank room. During this time period, several components in the tritium process system were found to have tritium leaks which led to tritium deposition on process skids, components and floor area.

Radiological surveys of surfaces contaminated with tritium oxide indicate a decrease in surface contamination in time (on the order of 12 to 36 hours) as the result of room ventilation. In instances where the facility HVAC system was maintained in the purge mode, a dramatic decrease in surface contamination was observed. Areas contaminated with tritium oxide (> 16.6 Bq/100 cm^2) were found to be clean (< 16.6 Bq/100 cm^2) after several hours of continuous purging by the facility HVAC system. In instances where relative humidity was not decreased, the tritium surface contamination was found to be attenuated. During the months of December 1993, January and February 1994 tritium leaking components were either replaced, redesigned or repaired. During this time period, data were collected in the form of contamination surveys, real time tritium monitor output, and HVAC configuration indicating the correlation of purge ventilation leading to a decrease in tritium oxide surface contamination.

1. INTRODUCTION

In December 1993, the Tokamak Fusion Test Reactor (TFTR) commenced its D-T regime.[1] Concurrent with this achievement, and in support of tritium operations at TFTR, it was found that several components in the tritium facility had tritium leaks which led to deposition of tritium on facility surface areas which included process skids, components, and floor areas.[2]

Prior to introducing tritium into the TFTR tritium facility, a series of Integrated Systems Test Procedures (ISTPs) were performed.[3] ISTP helium leak checking of tritium process systems were first conducted

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to specification leak rates of 1×10^{-6} cc of helium per component, with a total system leak rate specification of 1×10^{-5} cc of helium. After completion of helium leak checking, the system was subjected to low concentrations of tritium. During the performance of tritium leak checking ISTPs, tritium was injected into process piping and components. During this procedure a technician employing a hand held (portable) tritium monitor "sniffed" exterior process piping to determine if leaks had occurred. During this process, the specification for leak rates was established at < $1.85E^5$ Bq/m^3.

Although TFTR tritium systems were subjected to a detailed, comprehensive leak check, during the introduction of high concentrations of tritium several large tritium leaks (> $1.85E^7$ Bq/m^3), and approximately a dozen (< $1.85E^7$ Bq/m^3) small leaks were discovered. The leaks were the result of components which were found not to be tritium compatible, were thermally stressed during full tritium operation, or were stressed as the result of mechanical vibration from collateral process equipment.[4]

2. TFTR TRITIUM FACILITY

The TFTR tritium facility is comprised of the tritium vault, waste handling area, clean-up room, and gas holding tank room. The facility is serviced by a "once-through" heating, ventilation, and air conditioning (HVAC) system which maintains the facility at negative pressure zones and provides 8 air changes an hour.

Prior to commissioning the facility, the ceiling, walls, and floor were painted with an epoxy based sealant. This paint provided a smooth (poreless) surface which reduced surface area, and mitigated dust in the area from the previous bare concrete walls.

The tritium facility is serviced by a 1000 CFM tritium vault clean-up (detritiation) system (TVCS) with a rated Decontamination Factor (DF) of > 1000. The TVCS is presently set to initiate clean-up activities in the tritium area once an area tritium monitor reaches a set point of 80 μCi/m^3.

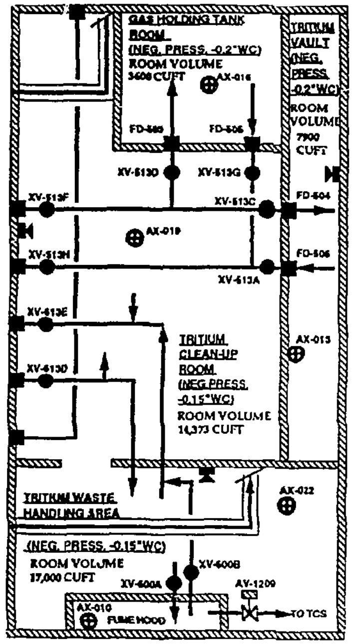
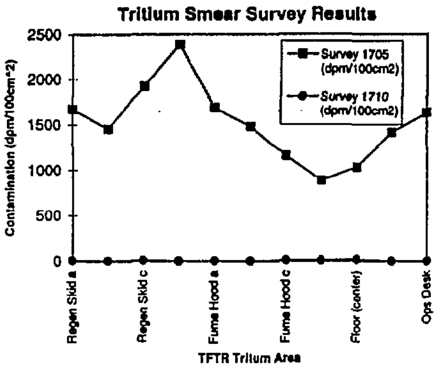


Figure 1. TFTR tritium area HVAC flow plan, with negative pressure zones.

Upon startup of the TVCS, all room ventilation is secured, and the room is isolated by tritium seal dampers. The TVCS maintains the area at slight negative pressure while processing and capturing tritium oxide on molecular sieve beds. As a result of TVCS operation, the relative humidity (normally 40%) of the tritium area is reduced to < 20%. During periods when the TVCS was employed (leaks of > $2.96E^6$ Bq/m^3 into the room) it was observed that room air tritium levels were attenuated, but the deposition of tritium oxide, as documented by surface contamination surveys, on surface areas remained well after the TVCS was disengaged from service. Once the normal HVAC configuration was re-established, it was observed that a significant decrease in surface contamination had occurred, and that surfaces which were previously contaminated > 16.6 Bq/100 cm^2 were subsequently reduced to background levels.

3. AREA RADIOLOGICAL SURVEYS



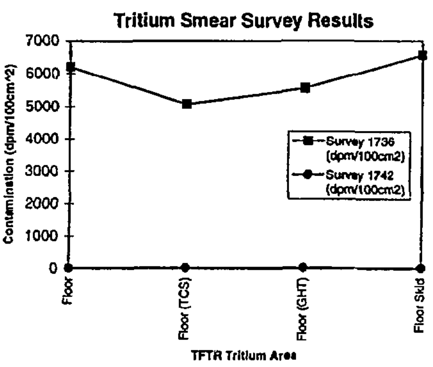


Figure 2. Survey data of tritium area after a tritium leak. Survey nos. 1705, 1710. Survey nos. 1736, 1742.

The above radiological survey data (surveys 1705, 1736) were taken immediately (within 2 hours) following a release of tritium in the tritium area. The subsequent radiological surveys (1710, 1742) were taken between 12-24 hours after the initiating event with the HVAC configured for normal operation (once-through, with area at negative pressures of 0.15" to 0.2" wc.) These surveys are typical of the effect when once-through flow HVAC is used on tritium oxide deposited on surfaces. The surface contamination in these cases has been reduced by orders of magnitude in a relatively short time.

In several instances (in the TFTR Test Cell Basement) when minor tritium spills occurred, it was possible to configure the HVAC system to the purge mode where air room changes were increased by a factor of 2.5 to 10. In this case, a dramatic attenuation of surface contamination was observed. This effect is amplified when local relative humidity is increased, thus sweeping moist air over contaminated surfaces and increasing the DF realized when employing the HVAC system.

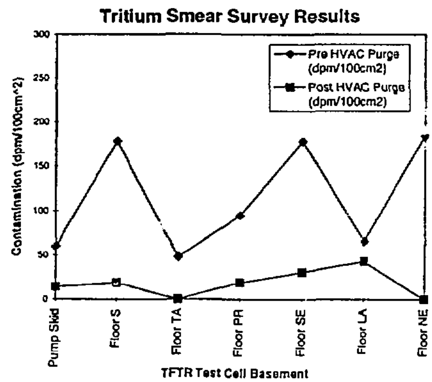


Figure 3. Survey data of TFTR Test Cell Basement.

4. SUMMARY

A direct correlation exists in the mitigation of tritium oxide on surfaces as a result of increased facility HVAC flow rates. In instances where relative humidity is increased above the controlled ambient, increased attenuation of tritium oxide contaminated surfaces are realized. The employment of the facility HVAC to mitigate tritium oxide contamination levels has led to an effective ALARA strategy in the operation of the TFTR tritium facility.

ACKNOWLEDGMENTS

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