

**Lack of Tritium Exit Signs Control and
Contamination of Landfill Leachate**



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**ASTSWMO Radiation Focus Group
Federal Facilities Research Center**

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Introduction

The Radiation Focus Group of ASTSWMO's Federal Facilities Research Center began researching tritium issues in 2003. At the same time, the U.S. Environmental Protection Agency (EPA) began conducting product stewardship activities concerning tritium containing devices; specifically self-luminescent tritium exit signs.

In 2003, the California Water Board evaluated 50 landfills for the presence of radioactive materials in landfill leachate. Above-background levels of tritium were found in leachate at 10 of these facilities.¹ In 2004, the Commonwealth of Pennsylvania began conducting a comprehensive two-year evaluation of 54 landfills that tested for the presence of radioactive materials in landfill leachate.² The study was conducted as a follow up to Pennsylvania's new requirements for radiation monitoring at solid waste management facilities and to confirm findings of the 2003 California study. In the Pennsylvania evaluation, above-background levels of tritium were noted in leachate at most facilities. Pennsylvania has done quarterly sampling for the past two years with similar findings. Studies in New York and New Jersey also have shown similar results.³ The source of higher-than-background levels of tritium found in landfill leachate samples is presumed to originate from the improper disposal of self-luminescent tritium exit signs found in construction and demolition (C&D) waste and other solid waste streams, as there are no other known sources of tritium in industrial or consumer products that would cause elevated levels of tritium in landfill leachate.

This paper is intended to serve as a source of information to assist State and Territorial program managers tasked with assessing tritium and solid waste disposal. Additional information on tritium can be located at the following:

- **Pennsylvania Department of Environmental Protection – Bureau of Radiation Protection**
http://www.dep.state.pa.us/brp/Radiation_Control_Division/Tritium.htm
- **Product Stewardship Institute (PSI)**
<http://www.productstewardship.us/displaycommon.cfm?an=1&subarticlenbr=191>
- **U.S. EPA – RadTown USA – Discarded Tritium Exit Signs**
<http://www.epa.gov/radtown/exit-signs.html>
- **U.S. Nuclear Regulatory Commission (NRC)**
<http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/tritium-radiation-fs.html>

¹ <http://www1.ciwmb.ca.gov/LEAMemo/2003/RadSurvey/WaterSample.pdf>.

² http://www.dep.state.pa.us/brp/Radiation_Control_Division/SolidWasteMonitoring/SolidWasteRadMonitoringReports.htm

³ http://www.hydroqual.com/publications/rdm_07_01_a.htm

Tritium Basics

Tritium (H-3 or T) is a radioactive form (or isotope) of hydrogen (H) that emits a low energy beta particle and decays with an approximate 12-year half-life. Tritium is often used in the gaseous form, but once released to the environment it readily oxidizes to form tritiated water (T₂O or TOH). Separating or removing tritiated water from normal water (stable H-1) is very difficult and impractical. Tritium is found at background levels in the environment from natural cosmic ray atmospheric production, past above-ground nuclear weapons testing, and, globally, is a routine nuclear power plant airborne emission. In recent years, there have also been reports of systems having leaked at research and nuclear power reactors causing local groundwater contamination. Normal environmental background tritium levels, as tritiated water, are approximately 50 to 150 picocuries per liter (pCi/L) in surface and near surface ground waters.⁴

Tritium Uses

There are many uses of tritium and tritium label compounds. The federal government is the largest user of elemental tritium in the United States for use in fission-fusion weapons. Because it is a radioactive hydrogen isotope, tritium is often used in biomedical research to tag and trace materials *in vivo* thru research animals, or *in vitro* using biochemistry methods. For example, certain molecules can be tagged with tritium and the fate determined by liquid scintillation counting or autoradiography. Similarly, tritium is used to trace ground water movement. There are also many applications of tritium self-luminous devices, where tritium gas fills a tube coated with a material (e.g., ZnS) that will emit light when struck by tritium's low energy beta particles. The glass tube prevents any radiation from escaping the device. Examples of these devices include exit signs, wristwatches, and compasses.^{5,6}

Regulatory Control of Tritium Exit Signs

The U.S. NRC allows the manufacturing of exempt and generally licensed (GL) devices that contain tritium⁷. An overview of GL uses and guidance documents are provided by the NRC at the following:

- General License Uses
<http://www.nrc.gov/materials/miau/general-use.html>
- NUREG-1556, Vol. 16. December 2000
 - Appendix K - Guidance for [10 CFR 31.5](#) General Licensees (Q&As).
<http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1556/v16/#48#48>
 - Appendix L: Guidance on Self-Luminous Exits (Q&As)
http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1556/v16/#_1_56

⁴ <http://www.nrc.gov/reactors/operating/ops-experience/grndwtr-contam-tritium.html>

⁵ <http://www.epa.gov/rpdweb00/radionuclides/tritium.html#use>

⁶ <http://www.nrc.gov/about-nrc/radiation/related-info/faq.html>

⁷ [10 CFR 31](#); [10 CFR 32](#)

A tritium exit sign is distributed as a GL device and may contain up to 25 curies (or 25,000,000,000,000 pCi) of tritium sealed in all the small glass tubes. The manufacturers of generally licensed self-luminous tritium exit signs are specifically licensed and must meet the safety criteria in [10 CFR 32](#) and in the table of dose limits in [10 CFR 32.24](#). A general licensee who receives a self-luminous tritium exit sign must appoint a “responsible individual” who is knowledgeable with the regulations and requirements for reporting events, transfer, and disposal of the device.⁸

In December 2006, the NRC mailed a Regulatory Information Summary (RIS) to general licensees to remind the regulated community of their responsibilities. A copy of the RIS is available at: <http://www.nrc.gov/reading-rm/doc-collections/gen-comm/reg-issues/2006/ri200625.pdf>

Impact on the Environment

Tritium is not an external hazard, but it may cause a radiation dose to humans when ingested or absorbed through the skin. Based on a 4 millirem per year (mrem/yr) dose limit, U.S. EPA has set a tritium maximum contaminant level (MCL) of 20,000 pCi/L for community drinking water supplies.⁹ However, California has established a lower Public Health Goal for tritium at 400 pCi/L.¹⁰ The NRC has set unrestricted area effluent concentrations for tritium from licensed facilities at 1×10^{-7} microcuries per milliliter ($\mu\text{Ci/ml}$) in air and 1×10^{-3} $\mu\text{Ci/ml}$ (or 6,000 pCi/L) in water.¹¹ If inhaled or ingested continuously over the course of a year, these concentrations would produce a dose of 50 mrem. There are no standards for tritium in landfill leachate; however, concerns relate to downstream sources of drinking water.

It is apparent that tritium exit signs are entering landfills via municipal or residual waste streams. When new, tritium exit signs may contain up to 25 curies (or 25,000,000,000,000 pCi) of tritium. The 2004 Pennsylvania studies indicate that over 90% of landfills had tritium above the 150 pCi/L normal background level, with over 50% above EPA’s MCL for drinking water. Pennsylvania studies also show leachate tritium levels in 2004 and 2005 ranged from hundreds of pCi/L up to 200,000 pCi/L. A single tritium exit sign has the potential to cause the tritium levels observed.

Pennsylvania has also assessed potential tritium exposure to onsite workers and the offsite public based on a review of many factors, including review of authorized discharges of treated leachate from treatment facilities, locations of public water supply intakes, and the uses of treated leachate or landfill gas. Although the Commonwealth concluded that there are no current threats to the public's health or safety associated with those discharges or practices, they are taking a proactive strategy to include continued monitoring and assessment of tritium in landfill leachate in order to provide continued

⁸ [10 CFR 31.5\(c\)\(12\)](#)

⁹ [40 CFR 141.16](#)

¹⁰ <http://www.oehha.ca.gov/water/phg/pdf/PHGtritium030306.pdf>

¹¹ [10 CFR 20.1301](#); [10 CFR 20.1302](#); [10 CFR 20 Appendix B](#)

protection of public health and safety and our natural resources. Implementation of this tritium strategy involves a collective effort of interdisciplinary resources within the Pennsylvania Department of Environmental Protection (DEP), primarily within Bureau of Radiation Protection (BRP), the Bureaus of Waste Management, Water Quality and Air Quality, and landfill operators.

Presently, landfill operators in Pennsylvania are sampling landfill leachate on a quarterly basis and submitting these samples to the DEP Bureau of Laboratories for tritium analysis. Results are being compared to a site-specific action level, based on dilution factors, set at a point where discharged, treated leachate might cause a down-stream water supply to exceed 10% of the tritium MCL. This has continued for nearly two years to trend tritium levels at each landfill. Follow-up quarterly sampling in 2007, 2008 and 2009 has noted levels as high as 350,000 pCi/L. At the conclusion of the two year study, Pennsylvania DEP will determine what long-term landfill leachate tritium sampling will be required.

Protection of the Public

The NRC does not require the registration of tritium exit signs. Many States require registration of tritium exit signs; however, most do not. In addition, some States routinely document lost or stolen tritium exit signs and report these events to NRC through the NRC's Nuclear Material Events Database (NMED) reporting system.

In the summer of 2006, Pennsylvania, using the NRC's mailing list, sent a notification to approximately 4,000 tritium exit sign general license (GL) holders who possess approximately 60,000 signs in the Commonwealth. Approximately 20% of the notifications were returned as "undeliverable," while many respondents did not know that they had a tritium exit sign(s) and many signs had exceeded their expirations dates.

Pennsylvania's Senate Energy and Environment Resources Committee also convened a hearing in June of 2006 to review the extent and implications of tritium in landfill leachate. The Committee discussed concerns related to high tritium levels having the potential to contaminate local ground water above the EPA's MCL of 20,000 pCi/L should landfill liners fail. Treated leachate at high concentrations (e.g., over 1E6 pCi/L) could have the potential to render a down-stream drinking water supply "vulnerable" to tritium, an EPA regulated radionuclide. In that tritium is not removed from leachate during treatment, only a site-specific assessment of dilution or direct tritium monitoring can determine where the finished drinking water concentration is in relation to the EPA's MCL of 20,000 pCi/L. The one Pennsylvania landfill with a measured leachate concentration as high as 350,000 pCi/L is treating the leachate onsite, has used the tritiated water for dust suppression, and is also permitted to discharge to a local stream. Such worker and public exposure pathways should be assessed.

In response to its notification results and to address the issue of tritium in landfill leachate, Pennsylvania DEP has requested NRC to amend its regulations to improve labeling and control of tritium exit signs. As noted above, NRC issued a regulatory

information summary (RIS 2006-25) in 2006 reiterating their requirements in [10 CFR 31](#) and [10 CFR 32](#) related to distribution, disposal, and appointment of a responsible individual. The NRC has also issued a request for information (RIF) from those organizations with over 500 tritium exit signs.¹²

As noted above, only a few States have documented landfill leachate with similar tritium concentrations. From 2005 to 2007, in a related aspect to tritium in landfill leachate, the NRC and the nuclear power industry expended thousands of manhours and millions of dollars evaluating similar tritium concentrations in groundwater around nuclear power plants.

In 2007, the Conference of Radiation Control Program Directors (CRCPD) expressed their growing concern with the ineffective regulatory control, inadequate labeling and improper disposal of tritium exit signs. Through discussion at their annual meeting and via an official Resolution, the CRCPD members commended the EPA for their efforts to mitigate the improper disposal of tritium exit signs and the NRC for issuing RIS 2006-25. However, CRCPD recommended that NRC and all States begin a national effort to actively alert general licensees with tritium exit signs of their regulatory obligations for control and disposal and to check expiration dates. Similarly, according to the CRCPD Resolution, States and NRC should continue to actively alert solid waste facilities, and the fire safety and building construction industries, as to the concerns related to tritium exit signs.¹³

While there is a growing concern in States over the regulation and disposal of tritium exit signs, several groups have developed guidance and training on how to safely handle and dispose of tritium exit signs, and how to respond to tritium releases. These include:

- **Kansas Department of Health and Environment – Gas Tritium Light Sources**
Provides guidance for the recovery of and response to damaged and/or broken tritium exit signs. This resource may be used as a guide for other States in responding to tritium releases. <http://www.kdheks.gov/radiation/radnews/9804.html#gts>
- **Product Stewardship Institute (PSI) – Tritium Exit Sign Stewardship**
In collaboration with EPA and other stakeholders, PSI has produced informational products pertaining to the proper handling and disposal of exit signs, including details on how and where to dispose of and recycle exit signs.
<http://www.productstewardship.us/displaycommon.cfm?an=1&subarticlenbr=191>
- **U.S. EPA - Responsible Management of Tritium EXIT Signs**
The U.S. EPA has developed an online and CD based training program to educate tritium exit sign users regarding proper handling and disposal. EPA's training program provides information on a number of topics, including an introduction to tritium and tritium exit signs, an overview of potential risks and health affects, and resources for proper regulation, handling and disposal of exit signs.
http://www.trainex.org/web_courses/tritium/index.htm

¹² <http://www.nrc.gov/reading-rm/doc-collections/news/2009/09-011.html>

¹³ http://www.crcpd.org/positions_resolutions/Waste_Mgmt/waste_20071114.html

Nonetheless, given the major public life safety risk of unrecognized expired tritium exit signs/reduced luminosity and the widespread environmental contamination that uncontrolled disposal has created, clearly the NRC must amend its regulations to address this situation.¹⁴ If this is done by NRC, Agreement States will need to amend their regulations in order to retain compatibility.

Problems with Tritium Exit Signs

The one major problem with tritium exit signs is regulatory control. The NRC's regulations require labeling of these devices, but the size of such labels is inadequate and an owner may not realize that it is subject to control by the NRC or an Agreement State. While the NRC did issue RIS 2006-25, submitted a Request for Information (RFI) to all users who have greater than 500 tritium exit signs, and created a fact sheet that highlights regulatory control, these actions were prompted primarily by State concerns and thousands of unaccounted-for exit signs.^{15,16,17}

One challenge States have observed is the numerous amount of tritium exit signs that have exceeded their manufacturer-stated expiration date. A tritium exit sign has a finite useful life due to the decay of tritium. Thus, the exit sign will decrease in luminosity and eventually fail to meet national fire safety criteria. The Product Stewardship Institute has identified disposal and recycle options for tritium exit signs; however, this continues to be a safety issue that will require continuous monitoring by local and State fire safety officials.¹⁸

As highlighted by Pennsylvania's outreach to general licensees in 2006, another challenge States are encountering is the tracking of exit signs. There are an estimated 2 to 3 million tritium exit signs in the United States. The general licensee who is in possession of a tritium exit sign may only transfer it back to the manufacturer or send it to a licensed entity for licensed disposal as low-level radioactive waste (LLRW).

From numerous reports of lost or stolen tritium exit signs by Agreement States and NRC, one can conclude that tritium exit signs are being disposed of in the normal solid waste stream.¹⁹ This is supported by the States that sample landfill leachate and find levels of tritium well above natural background. In addition to the 2004 and 2005 Pennsylvania studies, ongoing quarterly sampling and analysis of landfill leachate has yielded several landfills with concentrations in the 100,000 to 350,000 pCi/L range. As noted above, other surveys in the States of California, New York, and New Jersey have found similar levels.

¹⁴ <http://www.nema.org/stds/LSD13.cfm#download>

¹⁵ <http://www.nrc.gov/reading-rm/doc-collections/news/2009/09-011.html>

¹⁶ <http://www.nrc.gov/reading-rm/doc-collections/gen-comm/reg-issues/2006/ri200625.pdf>

¹⁷ <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-tritium.html>

¹⁸ <http://www.productstewardship.us/associations/6596/files/UpdatedTritiumExitSignDisposalDoc4-24-06.doc>

¹⁹ <http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2009/secy2009-0052/2009-0052scy.html>

Recommendations

The ASTSWMO Radiation Focus Group believes that the NRC should formally evaluate the submitted safety assessments for GL tritium exit signs with respect to disposal scenarios in solid waste transfer facilities, landfills and incinerators. The scope of an inappropriate disposal may range from a single sign to tens of signs, thus potential exposures need to be bounded. These safety assessments for GL tritium exit signs should fully assess tritium exposure scenarios via airborne and ingestion pathways.

The Focus Group recommends that NRC evaluate their regulations pertaining to generally licensed tritium exit signs, in particular, with respect to the size of labels alerting a user the exit sign contains radioactive tritium, the replacement date, and their proper transfer or disposal obligations. The Focus Group also recommends that NRC evaluate the need for a national and/or individual State-level tracking or registration program for tritium exit signs.