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Revision 0

2018 Annual Update on Tritium Removal Technology Developments

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

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TECHNICAL MEMORANDUM

2018 Annual Update on Tritium Removal Technology Developments

Prepared for:	Reg File 1004.7
Prepared by:	E. A. Hickey
CCs:	W. W. Rutherford
Date:	
Doc ID	CHPRC-03217, REV. 0

This evaluation supports the 2018 tritium technology development update. CHPRC conducted a search of information available on the World Wide Web to identify new candidate technologies that may be applicable to removal of tritium from contaminated groundwater. The results of this evaluation determined that the conclusions of the report prepared in *2014 "Evaluation of Tritium Removal and Mitigation Technologies for Wastewater Treatment"* still represent the best information to date.

To arrive at this determination, the previous reports were reviewed to define a basis for conducting a literature search. The internet search was conducted via the Google™ and Google Scholar™[1] search engines. Sources included lab reports, corporate press releases and product brochures, news articles and scholarly journals. The search started using the general tritium separation/removal topic, as well as those technologies listed in Table 1, *Summary of Tritium Removal and Mitigation Technologies* (DOE/RL-2014-10, *2014 Evaluation of Tritium Removal and Mitigation Technologies for Wastewater Treatment).*

The current technology review identified no major developments since the 2017 evaluation. The 2014 Evaluation and subsequent annual reviews anticipated that the first demonstration of a cost-effective, large-scale tritium removal technology for light water would be in response to the clean-up effort at the Fukushima Daiichi Nuclear Power Plant, operated by Tokyo Electric Power Company (TEPCO). However, in late 2017 TEPCO announced that due to issues with storage, the plant would be releasing the tritium-contaminated water into the ocean. While the company is currently awaiting the official approval of the Japanese government, TEPCO chairman Takashi Kawamura suggested that the decision had already been made (http://www.newsweek.com/fukushima-nuclear-waste-dumped-ocean-japanese-protests-637108).

It is unclear whether TEPCO plans to adopt a tritium removal technology in the future or if a slow release into the Pacific Ocean is the long-term solution. However, while most tritium removal technologies focus on heavy water tritium contamination, the disaster at the Fukushima Daiichi Nuclear Power Plant established an international interest in developing technologies for light water contamination. (https://nuclearstreet.com/nuclear_power_industry_news/b/nuclear_power_news/archive/2017/07/17/tepco-chairman-says-tritium_2d00_tainted-water-to-be-dumped-071702).

The TEPCO tritium removal technology verification grants, awarded to RosRAO, GE™[2] Hitachi Nuclear Energy Canada and Veolia Nuclear Solutions (Veolia), resulted in a combination of water distillation and combined electrolysis catalytic exchange (CECE) technologies for use in light water tritium separation

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[2] GE is a registered trademark of General Electric Company, Inc.

and removal. Of the three technologies, Veolia's Modular Detritiation System (MDS) could be practical for application on the Hanford Site in the future. (http://www.nuclearsolutions.veolia.com/en/our-expertise/technologies/tritium-removal-modular-detritiation-system-mds).

The MDS is advertised as a viable technology for tritium removal in high volume, low concentration waste streams with attention placed on providing a low energy intensive and low cost alternative to the conventional CECE tritium removal technology. Veolia's fully-licensed and permitted MDS, built and operating at Veolia's Richland, Washington office, was completed in March 2016 and passed acceptance testing. (http://www.nuclearsolutions.veolia.com/en/media/news/veolia-nuclear-solutions-prototype-tritium-removal-system-surpasses-international-readiness-benchmark-commercial-use).

As reported in the 2017 review, Veolia's MDS was tested under the internationally recognized Technical Readiness Assessment (TRA) in December 2016, achieving a Technology Readiness Level 6 (TRL-6). TRA's are procurement tools used to assess the commercial viability of promising new technology, and have been modified for nuclear applications by the U.S. DOE. TLR-6 status implies that the technology performed successfully in engineering-scale testing and is now reliably ready for deployment in commercial applications. (http://www2.lbl.gov/DIR/assets/docs/TRL%20guide.pdf).

CHPRC visited Veolia's office in Richland, Washington to observe the MDS in operation. While the system has been running for over 1,000 hours in a nine month period, the status of the technology has not changed since the 2016 TRA. The MDS would require significant modification, and the current prototype is not designed to meet the flow requirements or detritiation factors necessary for use at the Hanford Site.

In summary, based on this 2018 literature review, Veolia's MDS technology is still the most promising tritium removal technology currently under development. However, the full-scale system has yet to be implemented for either industrial or commercial use and Veolia has not released information regarding operational costs, long-term system performance or expected removal concentrations. This technology is not likely to be applicable to the Hanford Site without modification.
http://nuclearsolutions.veolia.com/sites/g/files/dvc1366/f/assets/documents/2017/03/Tritium_MDS_Tearsheet_January_2017.pdf).

Table 1. Summary of Tritium Removal and Mitigation Technologies

Technology	Year Report Prepared							
	1994	1995	1997	1999	2001	2004	2009/ 2014	Annual Review
Distillation	D, h		D, h	D, h	D, h	D, h	D, h	N
Gaseous diffusion	D, h							N
Laser isotope separation	T, h	T, h	T, h					N
Electrolysis	D, h	D, h	D, h					N
Combined electrolysis and catalytic exchange (CECE)	D, h	D, h T, l	D, h T, l	D, h T, l	D, h T, l	D, h T, l	D, h T, l	D, h T, l
Combined electrolysis catalytic exchange with vapor phase catalytic exchange					D, h			N
Membrane separation process	T, l	T, l	T, l					N
Cryogenic distillation	D, h	D, h	D, h	D, h	D, h			N
Bithermal catalytic exchange		D, h T, l		D, h T, l	D, h T, l	D, h T, l	D, h T, l	N
Isotopic exchange, air sparge		T, l						N
Finely divided nickel catalyst		O						N
Separation by Metanetix Inc.		O						N
Substituted naphthalene		O						N
Crown Ether Complexes		O						N
Girdler-sulfide Process			D, h	D, h	D, h	D, h	D, h	N
Palladium Membrane Reactor							D, h	N
GE™ Integrated Systems							D, h	N
Liquid phase catalytic exchange with solid oxide electrolyte			D, h	D, h T, l	D, h T, l			N

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	1994	1995	1997	1999	2001	2004	2009/ 2014	Annual Review
Liquid phase catalytic exchange with high-temperature steam electrolysis (Hot Elly)			D, h					N
Sulfur resin ion exchange			O					N
Metal hydride exchange			T, h					N
Soil column discharge	D, l, h		D, l, h	D, l, h	D, l, h	D, l, h	D, l, h	N
Barrier formation			O	D, l, h	D, l, h	D, l, h	D, l, h	N
Air sparging			T, l					N
Dual-temperature liquid-phase catalytic exchange				D, h				N
Tritium resin separation process				T, l	T, l	T, l	T, l	N
Kinetic-isotope effect for concentrating tritium				T, l	T, l			N
Pumping and recharging				D, l	D, l	D, l	D, l	N
Phytoremediation					D, l	D, l	D, l	N
Evaporation						D, l	D, l	N
Graphene oxide (GOx) laminar membrane separation							T, l	T, l
SAPO-34 molecular sieve zeolite membrane separation								T, h

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Technology	Year Report Prepared							
	1994	1995	1997	1999	2001	2004	2009/ 2014	Annual Review

GE is a registered trademark of General Electric Company, Inc.

D = Demonstrated or developed technology that has been successfully applied in the field

T = Testing or theoretical stage of development

O = Observation indicates a potential process needing funding to continue

Applicability:

l = Technology is applicable to larger wastewater volumes having lower levels of tritium (less than 1.0E-05 Ci/L)

h = Technology is applicable to smaller wastewater volumes having higher levels of tritium (greater than 1.0E-05 Ci/L)

N = Indicates that no new developments in technology maturity or applicability have been reported since last formal evaluation was performed