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17-AMRP-0132

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Addressees:

ANNUAL LETTER REPORT FOR TRITIUM TREATMENT TECHNOLOGY DEVELOPMENTS – MARCH 2017

This letter transmits the Annual Letter Report for Tritium Technology Developments for March 2017. This report is intended to provide an update on the development of treatment technologies pertinent to cleanup and management of tritiated wastewater and tritium contaminated groundwater at the Hanford Site.

Tri-Party Agreement M-026-07D requires submittal of a formal evaluation of the development status of tritium technology every five years. The next formal evaluation is due March 31, 2019. This letter constitutes completion of the Tri-Party Agreement commitment to submit an annual letter report in years that a formal evaluation is not required. The attached letter report summarizes the current status of the tritium treatment technologies, indicates treatment maturity, and defines treatment applicability.

M-026-07D
C-026-07K

If you have any questions, please contact me or your staff may contact Al Farabee, of my staff, at (509) 376-8089.

Sincerely,

Ray J. Corey, Assistant Manager
for the River and Plateau

AMRP:OAF

Attachment

cc w/attach:
G. Bohnee, NPT
J. V. Borghese, CHPRC
R. Buck, Wanapum
S. L. Brasher, MSA
S. W. Davis, MSA
R. H. Englemann, CHPRC
D. Goswami, Ecology
D. L. Halgren, CHPRC
S. Hudson, HAB
R. Jim, YN
N. M. Menard, Ecology
S. L. Nichols, Ecology
K. Niles, ODOE
R. E. Piippo, MSA
J. B. Price, Ecology
D. Rowland, YN
R. Skeen, CTUIR
Administrative Record
Environmental Portal

17-AMRP-0132

Attachment

This evaluation supports the 2017 tritium technology development update. CHPRC conducted an online search of information available to identify new candidate technologies that may be applicable to remove tritium from contaminated groundwater. The results of this evaluation determined that the conclusions of the report titled "DOE/RL-2014-10, *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 performing a literature search via the Google™ and Google Scholar™ internet 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 from the report titled *2014 Evaluation of Tritium Removal and Mitigation Technologies for Wastewater Treatment.* This table was updated to include the results from the annual review as identified in the last column (attached).

The current technology review identified a new membrane separation technology under development. A milestone report released by a Fuel Cycle Research & Development group at Oak Ridge National Laboratory (ORNL) described the synthesis and evaluation of silico alumino phosphate (SAPO-34) molecular sieve zeolite membranes to separate and concentrate tritiated water from dilute aqueous streams. The report noted that "[t]he goal in this proof of concept study is to evaluate the feasibility of separating tritium by taking advantage of the differences in adsorption and diffusion rates through the zeolite molecular sieve membranes." While tritium separation via membrane sieve has become a focus of recent development and testing, this technology focused more toward small volumes (0.5 to 1 Ci/L) of water with heavy tritium contamination, such as waste streams resulting from nuclear reactor wastewater. Membrane separation has not been proven successful for the high-volume, low-concentration wastewater found on the Hanford Site (http://info.ornl.gov/sites/publications/files/Pub61688.pdf).

The technology search also revealed that Kurion, which was recently bought by Veolia Nuclear Solutions (Veolia), is continuing to optimize and test its Modular Detritiation System (MDS) with the goal of achieving additional performance and cost improvements. Veolia's MDS is advertised as a viable technology for tritium removal in high-volume, low-concentration waste streams with emphasis on providing a low-energy intensive, low-cost alternative to the conventional combined electrolysis and catalytic exchange (CECE) tritium removal technology. The system was designed and developed in response to a contract with Tokyo Electric Power Company (TEPCO) for potential application to water contamination at the Fukushima Daiichi Nuclear Power Plant in Japan. The company's full-scale prototype MDS, built and operating at Veolia's Richland, Washington office, was completed in March 2016 and passed acceptance testing. Operating costs and actual tritium removal rates have yet to be released, but Veolia has said that it is currently in discussions with a number of customers to introduce its MDS technology.
(http://www.pgdpcab.energy.gov/pdf_files/FY2016_bulletin/03.02/ECA%20Update%203-1-16.pdf).

According to Veolia, the MDS has "surpassed a key international benchmark for commercial readiness while exceeding its design goals, confirming that the technology is suitable for widespread industrial application." The MDS was tested under the internationally recognized Technical Readiness Assessment (TRA) in December 2016. TRA's procurement tools are used to assess the commercial viability of promising new technology and have been modified for nuclear applications by the U.S. Department of

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Energy (DOE). The TRA committee reviewed the MDS and concluded that the system had achieved a Technology Readiness Level 6 (TRL-6) (http://kurionveolia.com/veolia-nuclear-solutions-prototype-tritium-removal-system-surpasses-international-readiness-benchmark-for-commercial-use/).

According to the DOE Office of Environmental Management's *TRA/Technical Maturation Plan (TMP) Process Implementation Guide*, a TRL 6 represents a significant increase in a technology's demonstrated readiness from laboratory to engineering scale and denotes that the concept is reliably ready for commercial applications. A TRL 8 represents the end of true system full-scale development (https://energy.gov/sites/prod/files/em/Volume_I/O_SRP.pdf).

In summary, based on this 2017 literature review, Veolia's MDS technology remains the most promising tritium removal technology currently under development. Veolia states that although it could begin processing Fukushima's water in as little as 18 months, Japan's government will likely take until 2018 to evaluate its technology. Veolia expects to implement MDS in the United States commercially before any results are seen at the Fukushima Daiichi Nuclear Power Plant (http://www.fukushima-is-still-news.com/2016/02/kurion-and-tritium-removal.html). While Veolia has yet to release information regarding the operational costs of the MDS, additional performance information is forthcoming as the technology becomes available for full implementation and TRL assessments are completed on system commissioning.

Table 1. Summary of Tritium Removal and Mitigation Technologies								
	Year Report Prepared							
Technology	**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					See below*
Cryogenic distillation	D, h	D, h	D, h	D, h	D, h			See below*
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
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

Table 1. Summary of Tritium Removal and Mitigation Technologies

Technology	Year Report Prepared							
	1994	1995	1997	1999	2001	2004	2009/ 2014	Annual Review
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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* Specific technologies using this treatment method are provided in the table.

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