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Tritiated water Challenge in Fukushima Daiichi

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Tritium Focus Group Meeting, April 2014

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Fukushima Accident

- Unit 1 (460 Mwe) – completely melted corium, hydrogen explosion
- Unit 2 (784 Mwe) – melted, most of the radioactive releases
- Unit 3 (784 Mwe) – much or all of the fuel melted, hydrogen explosion
- Unit 4 (784 Mwe) – defueled prior to, damaged from Unit 3 explosion
- Unit 5 (784 Mwe) – survived tsunami, to be decommissioned for training
- Unit 6 (1100 Mwe) – survived tsunami, to be decommissioned for training

- Currently water is circulating to cool fuels
- Radioactive radionuclide removed in the loop, but not tritium
- Accumulation extra 400 Ton/day due to ground water leakage
- Storage of tritiated water will approach 1 million ton by 2016

Source: Fukushima Accident , World Nuclear Association, updated 22 April 2014 (http://www.world-nuclear.org/info/safety-and-security/safety-of-plants/fukushima-accident)

- A treat rate of 1000 Ton/day is desired
- Energy very intensive: 500 Mwe by electrolysis, 300 Mwe by distillation

Quarterly Video Conferences between U.S. and Japan

US Decommissioning and Environmental Management Working Group

- Department of State
- EPA
- DOE IPA
- DOE-Tokyo
- DOE-EM
- LBL
- PNNL
- SRNL

Japan Decommissioning and Environmental Management Working Group

- METI - Japan Ministry of Economy, Trade and Industry
- IRID - International Research Institute for Nuclear Decommissioning
- TEPCO - Tokyo Electric Power Company
- JAEA - Japan Atomic Energy Agency
- MOE - Ministry of the Environment, Government of Japan
- NIES - National Institute for Environmental Studies

Overview – SRS Tritium Experience

Tritium – have produced and recovered kilogram quantities since early 1950s

- Tritium extraction
- Hydrogen isotope separation
- Tritiated water processing
- Material evaluation / development
- Analytical systems
- Separation and stripping
- Metal hydride storage
- Secondary confinement and processing
- Pumping
- Byproduct purification (e.g., ^{3}He)

Tritium in the Environment – over 60 years of studying and developing mitigation strategies for tritium & tritiated water in natural systems

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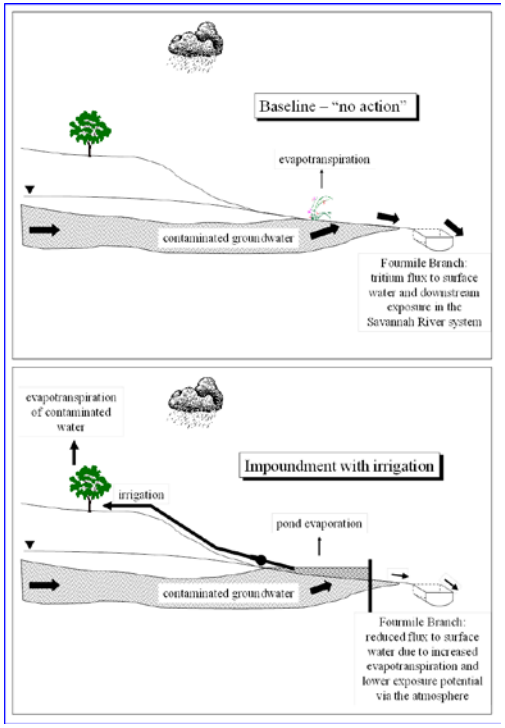
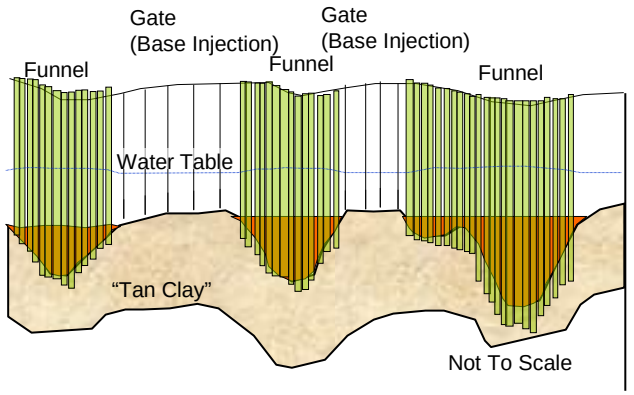
- Assessment / monitoring
- Sampling / characterization
- Grouting techniques
- Waste management
- Regulations and public relation
- Treatment / decontamination
- Mechanical and chemical cleaning
- Environment immobilization / barriers
- Modeling airborne release/ground water
- Ecology studies

Examples of Managing Tritium at the DOE Savannah River Site



Phytoevapotranspiration



Summary of Tritium Management in the U.S.

- Tritium in the U.S. is managed using ALARA (as low as reasonably achievable) principles
  - There is no fixed regulatory limit for dilution and release of tritium from nuclear facilities in the United States
  - Actions and Decisions are Risk-Informed and Risk-based
  - Includes Stakeholder Interactions
  - DOE Order 458.1 "… facility construction and operation so that releases of radioactivity are minimized so that dose to workers and the public are ALARA." Similar guidelines by Nuclear Regulatory Commission for private nuclear industry
- Management Practices
  - Containment and control, to the extent practicable, in facilities that produce tritium (includes hydrogen isotope separation for high activity systems such as moderator)
  - Controlled liquid releases via outfalls or gas releases via stacks
  - Immobilization (e.g., grout)
  - Innovative methods – evapotranspiration, other

ALL METHODS ARE CONSIDERED AND USED AS NEEDED TO REDUCE RISKS

Literature Examples - 1

- Review articles - no breakthrough in 30 years
  - H. K. RAE, “Selecting Heavy Water Processes” in Separation of Hydrogen isotopes, ACS Symposium Series 68, Washington D.C., (1978), Chalk River Nuclear Laboratories, Atomic Energy of Canada, Ontario, Canada
  - C. M. King, V. V. Brunt, R. B. King, A. R. Garber, “Concepts for Detritiation of Waste Liquids”, WSRC-MS-91-027, Savannah River Site, 1991
  - H. H. Fulbright, A. L. Schwirian-Spann, B. B. Looney, K. M.Jerome, V. Van Brunt, “Status and Practicality of Detritiation and Tritium Production Strategies for Environmental Remediation”, Savannah River Site, WSRC-RP-96-0075, 1996
  - D.J. Geniesse, G.E. Stegen, “2009 Evaluation of Tritium Removal and Mitigation Technologies for Wastewater Treatment”, DOE/RL-2009-18, Hanford Site.
- SRS publications related to tritiated water
  - L.K. Heung, G.W. Gibson, M.S. Ortman, “Tritium Stripping by a Catalytic Exchange Stripper”, Fusion Technology, Vol. 21, 588, 1992
  - L. K. Heung, J. H. Owen, R. H. Hsu, “Tritium Confinement in a New Tritium Processing Facility at the Savannah River Site”, Fusion Technology, Vol. 21, 594, 1992
  - P. Prater, G. Blount, T. Kmetz, K. Vangelas, “Forest Irrigation of Tritiated Water: A proven tritiated water management tool”, WM2013 Conference, February 24 – 28, 2013, Phoenix, AZ

Literature Examples - 2

- Selective references from other NNSA facilities
  - M. L. Rogers, P. H. Lamberger, R. E. Ellis, T. K. “Catalytic Detritiation of Water”, MLM-2437 (OP), Mound Laboratory, Miamisburg, Ohio, 1977
  - R. Scott Willms, Charles Gentile, Keith Rule, Chit Than, Philip Williams, “Mathematical Comparison of Three Tritium System Effluent HTO Cleanup Systems”, LA-UR-01-6198, Los Alamos National Laboratory, 2002
  - C.A. Gentile, S.W. Langish, C.H. Skinner, and L.P. Ciebiera, “Comparison and Evaluation of Various Tritium Decontamination Techniques and Processes”, PPPL-4006, Princeton Plasma Physics Laboratory, Princeton University, Princeton, New Jersey, 2004
- Attractive concepts for water detritiation
  - D. W. Jeppson, L. Furlong, G. Collins, “Separation of Tritium from Wastewater”, WM’00 Conference, February 27-March 2, 2000, Tucson, AZ
  - L. E. Furlong, S. L. Stockinger, G. B. Collins, “Method for Separating Heavy isotopes of Hydrogen from Water”, US Patent 6,632,367, 2003
  - J. B. Duncan, D. A. Nelson, “Separation of Tritiated Water from Water Using Composite Membranes”, WHC-SA-3009-A, Westinghouse Hanford Company, 1995
  - C. G. Woods, “Tritium Removal by Membrane Separation”, University Honors 458 Senior Honors Project, University of Tennessee, Knoxville, TN, 2001 (paper study based on the reported membrane property from Hanford)

Comments / Feedbacks

- High isotope separation factor processes
  - Laser isotope separation?
  - Staged electrolysis?

- Need “can-do” attitude from tritium community