

Hydrogen Hazards in Nuclear Facilities



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- What are the issues with hydrogen
 - Facilities with hydrogen concerns
 - Hydrogen generation
- Dealing with hydrogen
 - Quantifying hazards
 - Managing Hazards
- What are the research needs

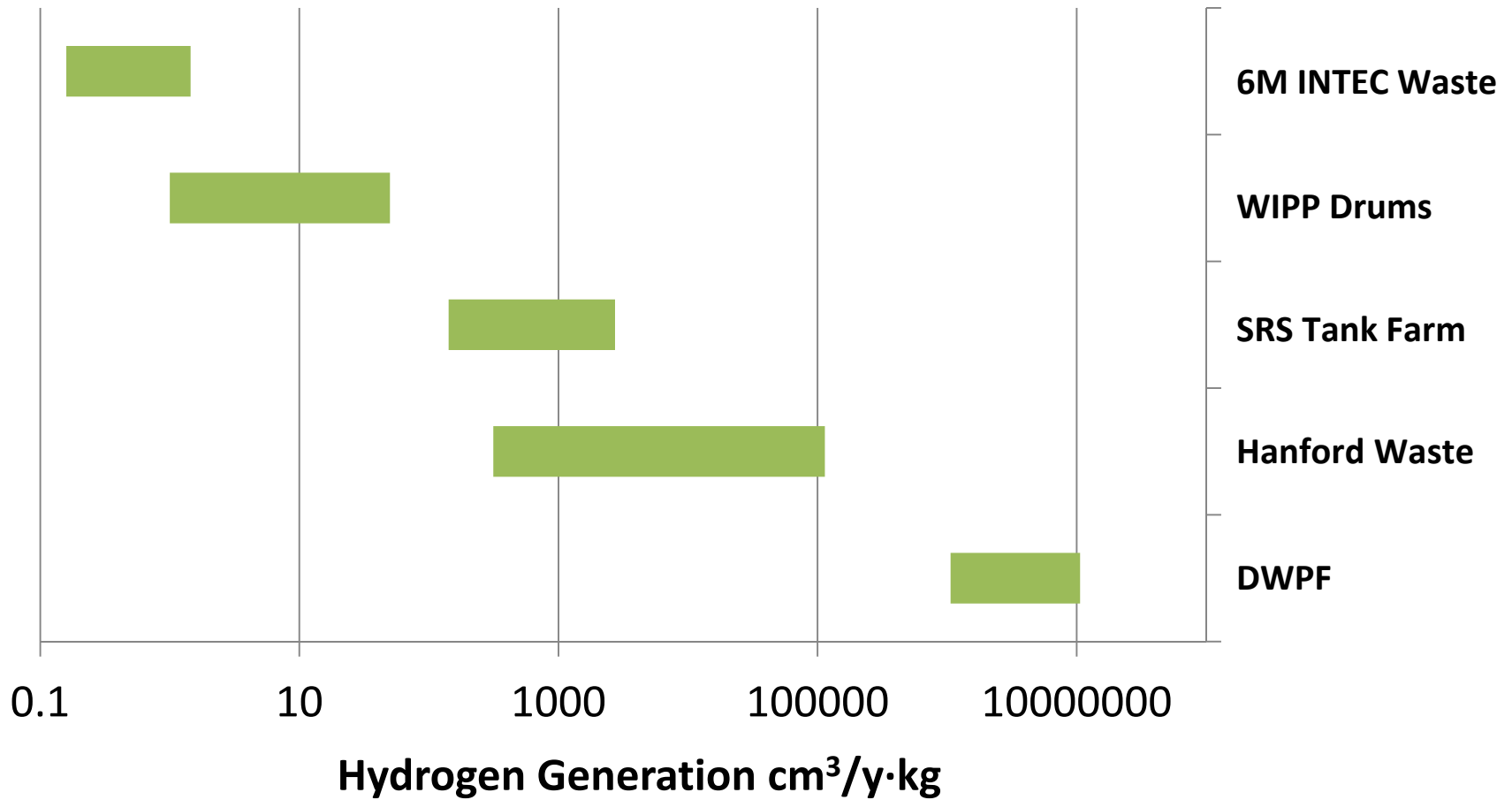
“Using a realistic approach to hydrogen management employing reasonable conservatism”

Facilities with Hydrogen Issues

- Liquid Waste Storage
 - Tank Farms (Hanford, Savannah River)
- Waste Treatment and Processing
 - Defense Waste Processing Facility (DWPF), Salt Waste Processing Facility (SWPF), Waste Treatment and Immobilization Plant (WTP), Integrated Waste Treatment Unit (IWTU)
- Packaging/Temporary Storage
 - Burial Grounds, TRU drums
- Long Term Storage/Permanent Disposal
 - WIPP, NTS
- Reactors

- Radiolytic Decomposition
- Thermolytic Decomposition
- Catalytic Decomposition
- Biological Hydrogen Production
- Use of Hydrogen in Process

Hydrogen Generation Rates



H2 Generation Rates in Tanks S-102 and SY-103

	Gas Generation Rate, mol/kg/day			Whole Tank Rate, mol/day	
	Thermal	Radiolytic	Total	Ref	Other
SY-103	3.5E-7	1.6E-6	2.0E-6	8.7	10*
S-102	1.6E-7	8.6E-8	2.5E-7	1.0	3.8*

Reference: PNNL-11600, Thermal and Radiolytic Gas Generation from Tank 241-S-102 Waste

* Estimated rates based on analysis of vent gases. Equivalent rate of approximately 3 ft³/day

Quantifying Hydrogen Hazards

- Samples
 - Tank, vessel, and drum head space
 - Monitor hydrogen levels
- Calculations/Models/Correlations
 - H₂ generation rate
 - H₂ deflagration/detonation events
- Test Programs/Experiments
 - Prevention
 - Mitigation
- Historical Knowledge
- These are largely done on case-by-case basis

Managing Hydrogen Hazards—Current Methods

- Combination of engineered and administrative controls
 - Prevent hydrogen buildup above LFL
 - Mitigate in case of detonation/deflagration
- Graded approach based on hydrogen generation rates
- Uncertainties lead to varying degrees of conservatism

Managing Hydrogen Hazards—Current Methods

- Monitor hydrogen levels
- Vent/Purge
- Manage agitation and mixing
- Monitor and manage chemistry and radioactivity (Waste Acceptance Criteria)
- Hydrogen Generation Rate Control Programs
- Engineered SSCs to withstand pressure of detonation/deflagration events

Conclusion

- Hydrogen generation can create safety issues at its nuclear facilities
- DOE is managing hydrogen, but largely done on case-by-case bases—labor intensive effort
- Not a simple solution
 - Cannot lose core knowledge
 - Better understanding of basic phenomena will streamline efforts
- QRA applications providing insights

BACKUP SLIDES

References

- WSRC-TR-2007-00200, *Evaluation of Radiolysis-Induced Hydrogen Generation in DOT 6M Drums from INTEC*, June 2007
- WSRC-TR-2004-00468, *Radiolytic Hydrogen Generation in Savannah River Site (SRS) High Level Waste Tanks—Comparison of SRS and Hanford Modeling Predictions*, August 2004
- M. Devarakonda, Letter to D. Mercer, *Estimation of Hydrogen Generation Rates from Radiolysis in WIPP Panels*, 26 July 2006
- WTP-RPT-115, *Gas Generation Testing and Support for the Hanford Waste Treatment and Immobilization Plant*, June 2004
- WSRC-SA-2002-00007 Rev. 10, *Concentration, Storage, and Transfer Facilities Documented Safety Analysis*, March 2009

References

- WSRC-TR-2003-00401, *Waste Tank Heel Chemical Cleaning Summary*, 9 September 2003
- 24590-WTP-PSAR-ESH-0 1-002-02 Rev. 4e, *Preliminary Documented Safety Analysis to Support Construction Authorization; PT Facility Specific Information*, 2 July 2009
- WSRC-SA-6 Rev. 28, *Final Safety Analysis Report Savannah River Site Defense Waste Processing Facility*, July 2009
- Kline, D. A. and Wentink, M. G., *Streamlining Hydrogen Controls in Piping Systems*, EFCOG Conference, Knoxville, TN 24 – 29 April 2010
- Askew, N. M., *Radiolytically-generated Hydrogen: SRS Experience*, JOWOG Technical Meeting, 21 April 2009