Hydrogen Safety Interest Group (H2SIG) Meeting
2014 EFCOG Safety Analysis Workshop

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Four Points Sheraton
Pleasanton, CA

October 13, 2014

Agenda

Monday, October 13, 2014
Accident Analysis Subgroup Meeting, 8:00 AM – 11:00 AM

Agenda for H2SIG Portion of AA Subgroup Meeting

Item	Time	Topic	Facilitator
1.	10:00 AM PDT	a. Hydrogen and combustible gas safety notes b. Status of Ongoing White Papers and Reports • LFL in Caustic Environments • Hydrogen/Tritium ARF/RF Paper • Panel Session Summary from PSA 2013 Topical Meeting on Nonreactor Facility Use of Probabilistic Risk Analysis (PRA)	Kevin O'Kula
2.	10:15 AM PDT	6M/2R Container Deflagration/Detonation Analysis Update	Karen Balo,UCOR
3.	10:40 AM PDT	Supplemental Hydrogen Production	Jackie East, BWCS DUF6/Paducah
4.	10:55 AM PDT	New Business & Plans for Next Dialogue	All

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Hydrogen and Combustible Gas Safety Notes - 1

- Electronic archival of useful H2 safety reports
  - EFCOG framework
  - Experimental data, applicable analytical methods, etc.
  - U.S., British, and international authors
- H2SIG website
  - http://www.efcog.org/wg/sa_hsig/index.htm
- DOE Hydrogen Program
  - http://www.hydrogen.energy.gov/
  - Incidents database found at http://h2tools.org/lessons/
- International Association for Hydrogen Safety
  - http://www.hysafe.info/

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Hydrogen and Combustible Gas Safety Notes - 2

- Panel Session at ANS Winter Conference (Anaheim, California) on Hydrogen and Combustible Gas Issues in Nuclear Safety
  - Tuesday, November 11, 2014
- Panel members
  - Michael V. Frank *(Waste Treatment Plant)*
  - Richard (Chip) Lagdon *(CNS, DOE)*
  - Joseph E. Shepherd *(Caltech)*
  - J. Kelly Thomas *(BakerRisk)*

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Hydrogen and Combustible Gas Safety Notes - 3

- TRITIUM 2016 Topical Conference on H-3 Safety, Science and Technology (http://tritium2016.org/)
- Charleston, SC – April 17-22, 2016
- Call for Papers – Late 2014
  - Biological Effects
  - Containment and Decontamination
  - Environmental Impacts
  - Measurement, Monitoring, and Accountancy
  - Safety and Waste Management
  - Tritium Processing (Purification, Isotopic Separation, etc.)
  - Interaction with Material
  - Tracer techniques and Isotopic Effects
  - Tritium Supply, Transport, and Storage
  - Tritium Breeding and Extraction
  - Water and Air Detritiation

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Status of Ongoing White Papers and Reports

1. LFL in Caustic Environments
2. Hydrogen/Tritium ARF/RF Paper
3. Panel Session Summary from PSA 2013 Topical Meeting on Nonreactor Facility Use of Probabilistic Risk Analysis (PRA)

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1. LFL in Caustic Environments

- Believed to be based on data and/or experience in the UK
- Contributors to the discussion included Sellafield Sites and Dr. Joe Shepherd (Caltech)
- Martin Fairclough noted work by Sellafield's University Partner, London South Bank University, into explosion mitigation; specifically about the effects of sodium hydroxide in water fogs
- Discussion
  - Work suggested that using a combination of the three measures (use of very fine water fog, nitrogen dilution and sodium hydroxide additives in the mitigation of hydrogen deflagration) together produces the optimal mitigation performance and
  - Can be extremely effective in: inhibiting the burning velocity, reducing the rate of explosion overpressure rise and narrowing the flammability limits of hydrogen-oxygen-nitrogen mixtures

Issues Raised by Dr. Shepherd

1. **Dependence of LFL on composition**. The gas phase flammability limit depends on the concentration of species in the gas phase. While the gas composition will depend on the chemistry of the liquid/solid waste (pH, etc.), I don't know of any correlation between the basic nature of the waste solution and lowering the flammability limit. This would require that the gases evolved from the waste solution significantly alter the other constituents in the gas beside hydrogen and air. Measurements of the gas phase composition and laboratory testing of flammability would be required to see if this is the case. For multicomponent mixtures containing fuels, the situation is much more complex that simply picking an LFL based on H2 concentration alone. Some variation on Le Chatelier's rule is needed to take the composition into account. A good example of this is for mixtures that contain ammonia – which usually does involve mixtures with higher pH – see the data and discussion in our paper published in 2000 http://www2.galcit.caltech.edu/EDL/publications/reprints/flimits.pdf
This and other data applicable to the Hanford waste tanks is discussed in PNNL-13269.
2. **Taking credit for ignition location and propagation direction**. Although it is well established that upward (4%) and downward (~8%) propagation limits differ in hydrogen-air mixtures, evaluation of hazards seldom take this into account. There are simply too many uncontrolled variables in most potentially hazardous atmospheres for this to be a good practice. Flame propagation near the LFL is quite sensitive to motion in the gas, both mean circulation and turbulence, as well as the location and strength of the ignition source. The outcome of an ignition event is also observed to be a strong function of scale – we observed in many tests in the 1980s on hydrogen combustion in nuclear power plants.

2. Hydrogen/Tritium ARF/RF Paper

- **Comparison of hydrogen/tritium values of ARF/RF from DOE-HDBK-3010 with Sellafield E1.30 SD6 performed by Terry Foppe**
- **Technical Guide E1.30 SD6, *Assessment of the Consequences of an Explosion***
  - Provides procedures/guidance for assessing consequences of a hydrogen explosion. Covers:
    - Detonation/Deflagration scenarios
    - Vessels/enclosures failure pressure
    - Effects on downstream filters
    - Radiological consequences
    - Conventional hazards and TNT equivalence
    - Low and zero consequence explosions.
- **Could not publish due to nondisclosure issues**
- **Would still provide value to H2SIG/AA members w/o British data**

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3. Panel Session Summary from PSA 2013 Topical Meeting on Nonreactor Facility Use of Probabilistic Risk Analysis (PRA)

- Session on Nonreactor Use of PRA/QRA Methods and Applications
  - Perspectives from regulatory, oversight, commercial, private organizations
  - Participants: Jim O'Brien (DOE/HSS), Yoshinori Ueda (Japan Nuclear Energy Safety), Mike Frank, Dennis Damon (U.S. NRC Staff), Jeff Shackelford (DNFSB Staff), and Dennis Heinneke (GE-Hitachi)
- Panel session minutes with presentations to be posted on H2SIG EFCOG site
- Expect to complete by end of October 2014

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6M/2R Container Deflagration/Detonation Analysis Karen Balo/1

Background

- Oak Ridge has 30 year-old containers of plutonium oxides with layered packaging
- Packaging is typically a pipe nipple or plastic bottle inside two nested foodpack cans, inside a 2R, inside a 6M drum, and nested in a 55 gallon drum
- Deflagration/detonation concern on hazards associated with opening these containers for repackaging in WIPP compliant containers
- Containers are currently in storage under the UCOR contract and would be processed by contractor for the Transuranic Waste Processing Center currently managed by WAI. The two contractors have worked jointly on this issue.

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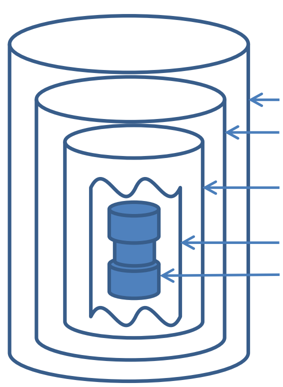
Typical Pu Oxide Container Packaging Configuration (Joe Jones, TWPC/WAI)



2R Container (5.047 in. ID[1] x 10.75 in. L)

Standard 404x700 convenience can (4.25 in. OD[2] x 7 in. L, with can wall and lid thickness of 0.0094 in.)

Standard 401x608 convenience can (4.0625 in. OD[2] x 6.5 in. L, with can wall and lid thickness of 0.0094 in.)

10 mil plastic bag (shown for configuration information only)

Pipe nipple (16.585 in.^{3} internal volume[3]) and (33.657 in.^{3} external volume[4]) and wall thickness 0.218 in.

[1] ID of container provided for determining H_2 concentration within the container.
[2] OD of container provided for determining ullage in surrounding container(s).
[3] Internal volume of container provided for determining H2 concentration within the container.
[4] External volume of container provided for determining ullage in surrounding container(s).

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6M/2R Container Deflagration/Detonation Analysis Karen Balo/2

Key Issues

- Dr. Veirs (Los Alamos National Laboratory) involved in evaluating the initial amount and associated partial pressures of hydrogen and oxygen
- DOE-STD-3013-2012 addresses ingrowth of hydrogen but not oxygen
- Studies on the nested configuration of 3013 containers show that the nested configuration shortens the L/D sufficiently to result in the transition of a deflagration to a detonation
- Uncertainty with respect to amount of oxygen available

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6M/2R Container Deflagration/Detonation Analysis Karen Balo/3

Current Status and Guidance Requested

- Calculations estimating hydrogen and oxygen production are near completion
- BlazeTech has analyzed concentrations to determine which containers represent a deflagration versus a detonation hazard
- Currently pursuing a contract with George Antaki to understand the progression and consequences of detonation
- Any thoughts or suggestions would be appreciated (karen.balo@ettp.doe.gov)

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4. Supplemental Hydrogen Production
Jackie East/DUF6

Guidance Requested

- The Depleted Hexafluoride (DUF6) Conversion Project produces hydrogen using commercially available generating units
- Hydrogen is used in the facility's DUF6 stabilization process.
- Looking to replace the current units with a combination of larger units and commercial tube trucks
- Any lessons learned from other nuclear facilities producing hydrogen or having bulk flammable storage would be greatly appreciated (jxeast@duf6.com; 270-538-2282)

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New Business & November Telecon

- New business items?
- Succession planning
- Next conference call - November 13
  - 07:00 Pacific/10:00 Eastern/15:00 UK

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