Generator Hydrogen Systems
Generator Users Group – November 4, 2015
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Agenda

- Hydrogen Safety
- Background on Hydrogen System Improvement Efforts at Duke Energy
- Generator Purging and Generator Purge Procedures
- Hydrogen System Painting, Labeling and Identification
- Hydrogen System Design and Maintenance Review
- Questions and Open Discussion
A 12-pack of standard hydrogen gas cylinders is equivalent to ~420 pounds of TNT and a typical hydrogen gas tube trailer is equivalent to ~5,585 pounds of TNT.
What you should know about H₂:

- Colorless, odorless and tasteless gas
- Odorants cannot be used with H₂
- H₂ rises in air at a speed of 20 m/s
- LEL/LFL – 4%, UEL/UFL – 74%
- Auto-ignition temperature of ~1050°F (565°C)
- Ignitable by static electricity
- Burns with a nearly invisible flame
Hydrogen fire safety:

- Keep all flammable / combustible materials at least 25’ from H₂ systems
- Verify adequate ventilation in the work area
- If possible, isolate the source of gas and allow the fire to burn itself out
- Use extreme caution when attempting to extinguish a leaking gas flame, spontaneous / explosive re-ignition may occur
- If necessary, all known extinguishing media can be used to fight a H₂ fire
Fatality occurred at Duke Energy’s Sutton Plant in Wilmington, NC in March 2011 as a result of a hydrogen explosion.

In response to the event, Duke focused on several corrective actions, a few of which included:

- Reviewed and revised fossil/hydro confined space procedure and confined space training program
- Standardized portable confined space monitors and purchased hydrogen leak detectors
- Reviewed and revised hydrogen purge and hydrogen unloading procedures
- Implemented a Procedural Hierarchy system across the fossil/hydro fleet
- Standardization of painting, labeling and identification on all station hydrogen systems
- Standardized intrinsically safe tooling inventory and established employee training on tool use
- Review portable hydrogen purge tri-gas (H₂, CO₂, Air) analyzer inventory and calibration schedules
- Address any additional hydrogen safety, operational, maintenance or system design concerns
Generator Purging & Generator Purge Procedures

- Generator $\text{H}_2 \rightarrow \text{CO}_2 \rightarrow$ Air purge overview:
Critical components every hydrogen-cooled generator purge procedure should possess:

- Clearly stated CO\textsubscript{2} volumetric requirements (number of pounds, bottles, etc.) that align with or exceed the OEM recommendation
  - Guidance regarding anticipated purge durations H\textsubscript{2} → CO\textsubscript{2} and CO\textsubscript{2} → Air is also strongly recommended (source of information can be from either the OEM or internal “tribal knowledge”)

- Procedural requirements to prevent CO\textsubscript{2} gas bottle / system freezing (frozen bottles or lines can limit the amount of gas administered and the effectiveness of the CO\textsubscript{2} during a purge)

- Operator verification that the gas purge analyzer’s (permanent and/or portable) calibration has been completed and is up to date
  - Note: Some analyzers may require spanning/zeroing out with calibration gas before beginning the purge
Generator Purging & Generator Purge Procedures

- Critical components every hydrogen-cooled generator purge procedure should possess (continued):
  
  - Requirement for gas purity readings to be taken during and upon completion of the $H_2 \rightarrow CO_2$ and $CO_2 \rightarrow Air$ purges
    
    - Purity samples should be taken directly from the stream of gas venting from the generator
    
    - Purity readings should be documented and independently verified
  
  - Procedural requirement to remove a spool piece in the hydrogen supply line to the generator, thus creating a fail-safe isolation between the generator and the source of $H_2$
    
    - $CO_2$ and Air spool pieces are also strongly recommended; procedural steps can be implemented to ensure that these spool pieces are inserted / removed such that $H_2$ and Air can never be mixed within the generator
  
  - Provisions for purging auxiliary piping (instrument lines, liquid level detector lines, etc.)
Generator Purging & Generator Purge Procedures

- Review and/or develop auxiliary H₂ equipment (i.e. hydrogen dryer) purge procedures

- Review and/or develop bulk hydrogen unloading procedures
  - Provide oversight to vendor offloading hydrogen at your site, key components include:
    - Pre-job brief / job hazard analysis execution and use of proper PPE
    - Pre-job inspection to ensure combustible / flammable materials are not within 25' of the work area
    - Installing wheel chocks and grounding the truck before offloading
    - Company oversight of vendor throughout entire offloading process (proper use of equipment, minimize traffic in the area, etc.)

- Procedural hierarchy system clearly defines expectations for procedure use and adherence
  - Continuous Use, Reference Use and Information Only

- Perform review of all purge procedures for accuracy and completeness with regard to configuration management as well as adherence to OEM processes/recommendations
H₂ System Painting, Labeling and Identification

- Corporate standard issued for hydrogen system identification based upon applicable codes (ASME B31.12, ASME A13.1, NFPA 2 and NFPA 55)
H$_2$ System Painting, Labeling and Identification
Hydrogen System Design and Maintenance Review

- Applicable hydrogen system codes & standards include the following:
  - OSHA Standard 1910.103 – Hydrogen
  - ASME B31.12 – Hydrogen Piping and Pipelines
  - ASME B31.1 – Power Piping (for $\text{H}_2$ systems designed and installed before the creation of B31.12)
  - NFPA 2 – Hydrogen Technologies Code
  - NFPA 55 - Compressed Gases and Cryogenic Fluids Code
  - CGA G-5.5 – Hydrogen Vent Systems
  - O.E.M. Design Specifications
Hydrogen System Design and Maintenance Review

Hydrogen system design and maintenance reviews and improvements at Duke Energy include:

- Adherence to ASME B31.12 – Hydrogen Piping and Pipelines:
  - Strict NDE requirements enforced for hydrogen piping systems including a minimum of 100% PT & VT of all pressure welds.

- Standard set of PM’s developed for fossil stations:
  - Annual leak checks performed on entire hydrogen system at each station.
  - Hydrogen system regulators / relief valves inspection and/or replacement.

- Hydrogen system vent location verification:
  - All hydrogen vent locations reviewed by engineering and relocated to safe locations (if necessary).
Hydrogen System Design and Maintenance Review

- Generator hydrogen purge manifold standardization & simplification
  - Added purge / sample locations, double block & bleed boundaries, etc.
- Underground, double-walled piping condition assessments and replacement
- Replacement of system valves not rated for H₂ service
- Non-hydrogen permeable thread sealant used for threaded connections as opposed to Teflon tape
Confined Space Monitors, Purge Gas Analyzers and H₂ Leak Detectors

- Strength and knowledge gained through fleet standardization and training initiatives
- Establish PMs for equipment based on OEM calibration method and frequency requirements (or write it into the applicable procedure to calibrate prior to use)
- Ensure the correct monitor and/or leak detector is used for the right application (i.e. not all confined space monitors detect hydrogen gas specifically, one would have to rely on LEL indication)