Lessons Learned on the DUF6 Conversion Project

May 2011

Richard Mayer

Safety Systems Oversight

What Is the DUF6 Conversion Project?

- Gaseous Diffusion Plants at Portsmouth, Ohio, Oak Ridge, Tennessee and Paducah, Kentucky processed UF_6 to produce enriched uranium
  - Tails material also produced (~700,000 metric tons)
  - No defined use – remained at each plant in large cylinders
  - Oak Ridge tails shipped to Portsmouth
- UF_6 is highly reactive
  - $UF_6 + 2H_2O \rightarrow UO_2F_2 + 4HF$
  - HF (anhydrous) is vapor, UO_2F_2 is water soluble

What is the DUF6 Conversion Project?

- Some Depleted UF_6 cylinders >50 years old
  - Condition beginning to degrade
  - Failures due to corrosion would release HF gas and soluble UO_2F_2 and would require remediation
- Project to convert UF_6 to more stable form
  - UF_6 fed to conversion unit
  - $UF_6 + 2H_2O \rightarrow UO_2F_2 + 4HF$
  - $UO_2F_2 + H_2 + H_2O \rightarrow UO_x + HF$ (unbalanced)
  - Filters separate solid U forms from gaseous HF
  - UO_x chemically, environmentally stable
  - HF condensed into 55 wt % HF acid (useable product)

Both DUF6 Conversion Facilities Passed ORRs in 2010

- Portsmouth
  - Contractor ORR passed in February
  - DOE ORR passed in May
- Paducah
  - Contractor ORR passed in July
  - DOE ORR passed in August

Safety Authorization Basis

- Conversion Facility is Hazard Category 3
  - Restricted to depleted U, no criticality hazard
    - Checks of enrichment made prior to cylinder delivery
  - Nuclear materials inventories maintained <Cat 2
    - Assured through Specific Administrative Controls (SACs)
- Three hazardous materials controlled as SS
  - UF6 – chemical hazard when in liquid/vapor states
  - HF – chemical hazard
  - Hydrogen – potential fire initiator, release UF_6, HF

Hot Functional Testing Phase

- Proceeds through sequence of tests
  - Process areas (VAP, CON, HFR, OPH, HFS)
  - Functional tests by area with hazardous materials
  - Integrated tests with systems working together
  - Define operating parameters
  - Determine changes necessary for safe, stable long-term operation
- Three Lines at Portsmouth, Four at Paducah
  - One line receives thorough testing
  - Bring other lines up leveraging experience from first line

Safety Authorization Basis

- Hot Functional Testing was performed under the safety basis established for operations
- The process parameters during the testing phase were constrained within the operational limits.

Startup Review Board (SRB)

Oversight

- Oversight of startup activities
  - Test instructions
  - Review of plant conditions
  - Activities during tests, including unforeseen events
- SRB includes Contractor, DOE representatives
  - Plant manager, Startup manager, Operations, Nuclear Safety, Quality, Health & Safety, Engineering
  - One DOE member
  - All members concur everything ready for test to proceed
- Test Plan of the Week
  - Gives permission to Operations to start each specific test
  - Several signatures, including DOE representative

SRB Role Provides Excellent Opportunity for DOE Oversight

- Ensures DOE is provided plans, test instructions and associated documentation (e.g., RWP, AHA) prior to commencement of activities
  - Review for errors, omissions
  - Review for Safety Basis compliance issues
  - Avoid problems during testing
- Approval role ensures DOE concerns addressed
  - Cannot direct contractor actions
  - Can withhold approval to proceed

Oversight Lessons Learned

- Helpful to build relationship with contractor personnel
  - Resolve differences in Safety Basis interpretation
    - Example: when specific TSR requirements are applicable
  - Communicate with personnel to avoid TSR violations
    - Example : Plan to open valve when not in correct MODE
  - Hold meetings to resolve identified problems
    - Example: Discuss methods to remain within analyzed conditions in Safety Basis and still conduct needed tests
  - With good relationship, more likely to stay informed on developing issues
- Understand inner workings of process and effects of safety basis controls on operations.
  - Example: BPCS controls

Operational Readiness Review Lessons Learned

- Make sure DOE is ready to perform oversight
  - Much effort spent ensuring contractor organization ready
  - Nuclear Safety Oversight Lead emphasized the need to make sure DOE oversight personnel ready (qualifications)
  - Both organizations will be reviewed
  - Contractor has CORR, does not review DOE at that time
- Conduct business as usual during ORR
  - More representative of day-to-day roles
  - Less likely to make mistakes (most of DORR team's observations were on things unintentionally done differently during DORR)

DOE Oversight Staff Qualification Lessons Learned

- Process seems daunting to new personnel
  - >10,000 pages of required reading
  - >50 different documents to know
  - Not accustomed to Oral Board format of testing
- Practice helps
  - Conduct walk-downs with experienced personnel
  - Quiz one another
  - Conduct mock oral boards with peers
- Break into manageable portions
  - Start with learning process and plant configuration
  - Learn Safety Basis (DOE and Contractor-sponsored training)
  - Learn DOE regulatory basis
  - Other information (contracts, local DOE policies, etc.)

Safety Basis Lessons Learned

- Nuclear Safety personnel generally less familiar with chemical hazards analysis and standard industrial practices
  - Tend to be overly conservative
- Testing should be more thoroughly evaluated during SB development
  - TSR TEST MODE would be helpful
  - Different operations during testing need to be considered
- Safety Basis development should factor in the learning process associated with scaling up process systems
  - The range of operating parameters are typically poorly defined in a new or scaled up process.
  - Testing tends to generate a larger fraction of off normal process conditions (low flows, low concentrations) compared to routine operations.
  - The hot functional testing process has provided a great opportunity for operations to learn how to effectively implement safety basis controls, and has provided many lessons learned that will be incorporated into the next safety basis update.

Unexpected Events Will Occur

- Cross-contamination event
  - Valve indicator not working, partial conversion unit nozzle plugging occurred (unrelated to valve), purge line common to two units
  - Control software took action operators did not expect
  - UF_6 fed to non-operating conversion unit, not converted to solids, went through filter to 'clean' side of system
- More questioning attitude could have prevented
  - Contractor convinced OK to proceed with bad valve indicator
  - Could have asked what else control system might use valve indicator signal for
  - Could have reduced effect by more closely observing other process variables
- DOE and contractor have different goals
  - Contractor – focused on meeting short term milestones and earning fee
  - DOE – focuses on achieving the mission safely and balancing project resources and needs

Conclusion and Path Forward

- The Integrated Project Team continues to incorporate Lessons Learned in the DUF6 project
- New contractor selected for operation of the facilities
  - Using a phased startup
  - Planning Safety Basis revision
    - Maintain safe operation
    - Re-evaluate accident analyses for some chemical hazards
    - Include mode tailored for maintenance activities
    - Address Operations personnel comments
- DOE adjusting oversight approach for end of HFT, beginning of normal operation of the plant