Safety Basis Development/Implementation for "Limited Life" Facilities

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Abstract

This paper describes the process utilized to develop and implement the Safety Basis for operation of the Pine Bluff Chemical Agent Disposal Facility (PBCDF). Since the expected operational life of the facility will be limited, a "graded" approach to Safety Basis development was pursued. The analysis was generally qualitative. The Safety Basis had to be developed and implemented in a very short time period with limited staff. Unlike DOE Facilities, the format was not specified and there was little to no proven implementation guidance; therefore, maximum advantage was taken for engineering judgment where applicable, instead of additional detailed calculations. However; the analysis was sufficiently thorough to ensure that all significant hazards were systematically identified and adequate controls were implemented to protect the Public and Collocated Workers. These challenges were exacerbated by the fact that many of the defined "Evaluation Basis Accidents" (EBAs) were low frequency/high consequence as well as the physical location of the facility. This experience demonstrated that it is possible to control and reduce risk to acceptable levels while tailoring the safety envelope and implementing actions to be commensurate with relative importance to safety, consequences of the hazards, and site specific characteristics even when faced with limited staff/resources. This paper also addresses other unique challenges associated with chemical demilitarization operations and the "lessons learned" from the safety analysis process. Reviewing the lessons learned and benefits derived from this evolution may "Support Excellence in Operations Through Safety Analysis." The main beneficiaries are anticipated to be "fast track" and "limited life" projects.

Introduction

The Pine Bluff Arsenal (PBA) is located in south-central Arkansas near the town of White Hall (population ~6,000), approximately 8 miles northwest of the city of Pine Bluff (population ~57,000), and thirty miles southeast of Little Rock (population ~185,000). The physical location of the PBCDF within the PBA is near the Arkansas River, a major navigable waterway. Pine Bluff Chemical Activity (PBCA) stores approximately 12% of the nation's original stockpile of chemical munitions. The chemical agents fall into three basic categories: nerve agent VX, nerve agent GB (Sarin) and mustard agent HD/HT. These chemical agents are contained in rockets, land mines and bulk containers. Chemical weapons have served as a powerful United States military deterrent over the past 50 years; however, the changing global political climate has resulted in the need to eliminate the nation's stockpile of munitions and the chemical agents used in their manufacture. Public Law 99-145 as amended by Congress in 1985 directs the United Sates Department of Defense (DoD) to destroy the stockpile of unitary chemical agents and munitions. The commitment was ultimately established on a world-wide basis through ratification of the Chemical Weapons Convention. The United States Army built a hazardous waste treatment facility for the destruction of the chemical agent stockpile located within the PBA. The destruction and elimination of the stockpile will be accomplished by first separating

the chemical agents, energetic components and munitions/container hardware. Each of these items will be treated separately by incineration. Chemical agent disposal operations commenced March 2005 at PBCDF and the facility is currently scheduled to be operational for 65 months.

Developing a Safety Basis

The purpose for developing a Safety Basis is to define the analytically derived safety envelope for chemical demilitarization operations. The safety envelope is based upon the facility design and the analysis of site-specific EBAs. By operating and maintaining the facility within the controls and limitations defined by the safety envelope, Washington Group can assure that chemical demilitarization operations will be conducted in a manner that ensures the safety of the Public and Collocated PBA Workers. Accident consequences to PBCDF personnel were not explicitly considered when establishing the Safety Basis because facility workers are issued an M40 Protective Mask and provided training in the proper use of the mask as well as training in facility specific hazards and emergency response actions. Safety for Facility Workers is addressed by DoD, OSHA, and Standard Industrial Safety Practices and Programs.

The work scope for developing the Safety Basis included the following activities:

- Select appropriate site-specific Evaluation Guidelines
- Identify potential unmitigated accidents that could challenge the Evaluation Guidelines
- Select controls, which prevent or mitigate the risk well below the Evaluation Guidelines, and
- Define the safety function and establish performance standards for the selected controls

The Evaluation Guidelines were based on the Acute Exposure Guideline Levels (AEGL). The AEGL were determined to be the most applicable data for developing chemical agent exposure guidelines. AEGL are chemical exposure time-dependent concentrations that indicate the levels above which different irreversible, long lasting, adverse health effects (including death) could begin to occur in the general population. One advantage of using AEGL is that they correlate well with the Emergency Response Planning Guidelines (ERPG) concept. However, since the AEGL were developed to address effects to more sensitive individuals, such as infants, children and others that may be more susceptible to lower concentrations than the rest of the population, the values tend to be more stringent than corresponding ERPG. The AEGL also address the human body's ability to process agent.

Washington Group utilized Science Applications International Corporation (SAIC) to support the development of the Safety Basis. SAIC screened the site-specific Quantitative Risk Assessment (QRA) document to identify potential unmitigated accidents that could challenge or exceed the defined Evaluation Guidelines. Accidents associated with continued in-situ storage and disposal were identified utilizing industry accepted hazard analysis techniques such as Hazard and Operability Studies (HAZOPS), What If Analysis, Failure Modes and Effects Analysis (FMEA), or Fault Tree Analysis supplemented by lessons learned and subject matter expert opinion. Many of the identified accidents were low frequency/high consequence. Since the purpose of the Safety Basis is to evaluate bounding credible accidents, scenarios with frequencies less than 10^{-8} were screened out as incredible. Potential consequences to designated receptors from a

chemical agent release were determined by quantifying the airborne source term. Unmitigated release scenarios were evaluated under the following conditions:

- No credit was taken for active safety features
- Passive features (e.g., facility structure, etc.) were credited to the extent that they could withstand the accident
- Physical processes that reduce total airborne source term such as agent destruction during fire events were credited

Mitigated release scenarios were evaluated by iteratively applying controls until the consequences are acceptably low and below the Evaluation Guidelines. The Evaluation Guidelines were not interpreted as discrete pass/fail criterion. Any result that is close to the guideline is considered to "challenge" it; therefore, controls must be credited until the result is sufficiently below the guideline such that it is no longer "challenged". Engineering judgment was utilized to determine when an adequate safety margin existed. The safety function and performance criteria for each active engineered safety feature (e.g., Heating, Ventilating, and air conditioning (HVAC), automatic fire detection/suppression, etc.) were defined. The structures, systems, and components (SSC) that were credited in the mitigated release scenarios were considered to be "Important-to-Safety". Operability of these systems is ensured by the Limiting Conditions for Operation (LCO). Required management programs and administrative controls were also identified during the mitigated release evaluation. Defense-in-Depth was demonstrated by ensuring that at least two primary controls exist for each EBA, which are each independently capable of mitigating the accident consequences below the Evaluation Guidelines (e.g., "double contingency principle").

The Safety Basis will be maintained as a "living document" throughout the operating life of the facility. All changes to SSC and/or procedures will be screened/reviewed for potential impact to the Safety Basis in accordance with a modified Unreviewed Safety Question (USQ) Process similar to the process required by 10 CFR 50.59. When appropriate, revisions to the Safety Basis and LCO will be implemented. Facility staff will receive training on the Safety Basis and LCO.

Quantitative Risk Assessment (QRA)

As stated above, the QRA was used to develop the Safety Basis. The QRA is a comprehensive analysis developed by SAIC[1] for the Chemical Materials Agency, to exam the risks that could cause the greatest harm to the Public and Collocated PBA Workers associated with potential accidental releases of agent during disposal operations and continued stockpile storage. Literally thousands of potential accidents, including very rare events, were considered. These accidents were predominantly related to:

- Human error
- Equipment failure
- Explosion or combustion of energetics
- Loss of support systems
- Natural phenomena, and
- External influences (with the exception of sabotage)

Using the QRA as a basis for risk management to develop the Safety Basis was appropriate because:

- The QRA is comprehensive. Rigorous analysis has been done for a much wider range of accidents than required
- The QRA identifies all agent related risk contributors (internal and external events)
- The QRA allows comparison of disposal operations versus continued stockpile storage
- The QRA allows comparison of facility operation risks versus other common lifetime risks
- The analysis was thoroughly reviewed and sanctioned by the National Research Council, and
- Accident frequencies and source terms are readily available

Limiting Conditions for Operation (LCO)

The Safety Basis was the primary input for development of the LCOs. LCOs were defined for all SSC and the associated support systems specified in the mitigated release scenarios. One or more Surveillance Requirements were specified for each LCO. Satisfactory performance of the Surveillance Requirements within the required periodicity is necessary to ensure compliance. Design Features and Administrative Controls were also specified. The LCOs are strictly based on quantitative risk/accident analysis as defined by the Safety Basis. If LCO limits are exceeded, the direct result could be failure of the barriers that prevent uncontrolled releases of chemical agent, with potential consequences to the Public and Collocated PBA Workers above the evaluation guidelines. The LCO format was benchmarked from Government Owned Contractor Operated DOE Facilities and commercial Nuclear/Power Industries.

Safety Basis Implementation and Maintenance

Required controls have been incorporated directly into the Standing Operating Procedures (SOP), Plans, Procedures, and Work Instructions. Due to the importance of these controls in preventing/mitigating the consequences of the EBAs, a higher operator performance emphasis is required. This emphasis is provided using "flags" to denote Safety Basis/LCO requirements to ensure that critical steps are not changed or removed without adequate review. Compliance with LCOs is verified on a continuous basis and prior to Mode changes (e.g., Shutdown to Standby to Operation). LCO compliance is demonstrated by:

- Operating within process ranges or set points specified by approved SOP
- Operating within the specified Required actions of the LCOs or Response Plans when required
- Performing all Surveillance Requirements within the allowable periodicity
- Maintaining/Controlling the configuration of Design Features
- Establishing and implementing Administrative Controls

LCO compliance is routinely established by observing normal operations as part of the Shift Turnover Process [Conduct of Operations (CONOPS)]. A well documented Shift Turnover will establish LCO compliance and authorize continued operation. A number of tools have been developed to assist Operators in verifying that LCO compliance is maintained. Entry into LCO conditions may be identified by reviewing the following resources:

- Logbooks
- Equipment Status Boards/Logs
- Control System Screens
- Operator Round/Reading Sheets
- PDAR
- TRAC Database and Crystal Reports
- Condition Reporting System

Unsatisfactory performance or non-performance of the Surveillance Requirements requires entry into the LCO Condition and performance of specified required actions. Operations shall track entry into/exit from known non-compliant LCO Conditions (e.g., missed surveillances, unacceptable surveillances, etc.). Although the Design Features and Administrative Controls do not have specified surveillance Requirements and corresponding actions; these controls must be established/maintained. Status of LCO Conditions shall be addressed as part of the Shift Turnover Process.

Lessons Learned

This experience demonstrated that it is possible to control and reduce risk to acceptable levels while tailoring the safety envelope and implementing actions to be commensurate with relative importance to safety, consequences of the hazards, and site specific characteristics even when faced with limited staff/resources. The main beneficiaries are anticipated to be "fast track" and "limited life" projects.

- The single greatest risk to the Public and Collocated PBA Workers results from continued stockpile storage (especially with regard to GB/VX rockets). Accident analysis needs to be sufficiently conservative to demonstrate that chemical agent releases following an EBA will not exceed the Evaluation Guidelines. This was accomplished by incorporating "Safety Margin".
- Safety Margin was demonstrated by:
    - Establishing conservative chemical agent release thresholds (Evaluation Guidelines) for a spectrum of challenges to the facility
    - Designating certain controls that prevent or mitigate the challenges as "Important to Safety" SSC, which are held to a higher standard of performance, design, manufacture (quality control), and maintenance than other facility equipment
    - Providing Defense-in-Depth (e.g., "Double Contingency")
- The analysis was significantly simplified by defining "mass-based" Evaluation Guidelines, which eliminate the need to establish and justify precise release times. In this manner it will only be necessary to quantify the release fraction, determine the total source term, and compare this against the Evaluation Guideline while

ignoring release duration or effects of changing release rates over time due to meteorology variances. The closer the selected thresholds are to the actual calculated accident release concentrations (e.g., the more precise the calculation), the less Safety Margin is provided

- Due to the fact that many of the potential EBAs are low frequency/high consequence, probability and frequency had a limited role in the unmitigated accident analysis. Frequency ranges were not absolute
- A minimum number of LCOs should be specified in order to more effectively emphasize their importance and ensure compliance
- To facilitate the Operators, LCO compliance verification was integrated with Operational Readiness Reviews and Conduct of Operations (CONOPS). The process built upon existing Preventive Maintenance and Operator actions where possible for performance of LCO surveillances.
    - LCO Condition tracking and awareness was proactively implemented for more effective utilization of Operations Personnel.
    - A unique facility report was developed that assisted Operators with LCO compliance decisions.
    - A well-documented Shift Turnover will establish LCO compliance and authorize continued operation.
- Use of existing Management Programs to satisfy Safety Basis commitments has proven to be very effective.

Results

Safety Basis Document (SBD)/ LCO development took full advantage of pre-existing safety and environmental compliance documents. Since no format was specified, the initiative benchmarked from Government Owned Contractor Operated Facilities and commercial Nuclear/Power Industries that have demonstrated excellence in safety analysis. Knowledgeable subcontractors were used to supplement facility staff in the performance of accident analyses. The PBCDF started "Chemical Agent Operations" on schedule. Initiation of operations was declared to be the "safest and most efficient startup in assembled chemical warfare history" by Washington Group Corporate Management. The facility has most recently celebrated more than 2 years of successful chemical weapons disposal operations, more than 900,000 pounds of chemical agent has been eliminated. Since the start of processing the total programmatic risk has been reduced by approximately 75% and the PBA storage risk has been reduced by approximately 63% while consistently maintaining safety performance records that are among the best ever achieved in the Chemical Demilitarization Industries.

References

1 Science Application International Corporation (SAIC), Pine Bluff Chemical Agent Disposal Facility (PBCDF) Quantitative Risk Assessment, Abingdon, Maryland, October 2003