Red Hill Bulk Fuel Storage Facility (RHFSF)

Quantitative Risk and Vulnerability Assessment (QRVA)

Work Plan Outline (Draft Crev1)

I. Introduction
   a. Purpose
   b. Background
   c. Objectives
   d. Administrative Order on Consent Statement of Work – Section 8
   e. Navy Contract QRVA Statement of Work
   f. QRVA Level and Scope Determination

II. QRVA Proposed Methodology
   a. Internal Events QRVA for Loss of Fuel Inventory Control (Level 1)
      i. Information Collection
      ii. Facility Familiarization and Information Review
      iii. Definition of Fuel Release Protective Functions
      iv. QRVA Bases and Assumptions
      v. Initiating Events Analysis
         1. Engineering Evaluation
         2. Master Logic Diagram Development
         3. Initiating Event Category Definition
         4. Initiating Event Frequency Determination (see Data Analysis)
      vi. Event Sequence Analysis
         1. Event Sequence Diagram Development
         2. Event Tree Development
            a. Functional Event Tree Development
            b. System and Train Level Event Tree Development (including Event Tree Top Event Definition, Ordering, Split Fraction Definition, End State Definition, Binning, etc.)
            c. Definition of System Success Criteria
            d. Dynamic Human Action Addition to Event Trees
            e. Event Sequence Recovery Action Addition to Event Trees
            f. Event Tree Split Fraction Logic Rule Development
            g. Event Tree Binning Rule Development
      vii. Systems Analysis
         1. Specification of Analysis Ground-rules and Model Resolution

2. System Dependency Matrix Development
3. Boolean Logic Model (e.g., Fault Tree) Top Event Definition
4. System Failure Modes and Effects Analysis (FMEA)
5. Boolean Logic Model (e.g., Fault Tree) Development
    a. System Hardware Failure Mode Logic
    b. Incorporation of Maintenance and Testing
    c. Incorporation of Human Error
    d. Incorporation of Dependent Events (e.g., Common Cause Failure)

viii. Human Reliability Analysis
1. Human Failure Event (HFE) Definition and Evaluation
    a. Operations, Maintenance, Testing, and Emergency Procedures Review
    b. Operator Interviews and Scenario Walk-throughs
2. Human Error Probability (HEP) Evaluation and Analysis
3. Human Action Dependency Analysis

ix. Data Analysis
1. Generic Data Analysis
    a. Initiating Event Frequency Determination
    b. Component Failure Mode Failure Rate Determination
    c. Component Failure Restoration Time Determination
2. Facility-Specific Data Analysis
    a. Facility-Specific Data Collection, Review, and Interpretation
    b. Bayesian Updating of Generic Data with Facility-Specific Evidence
3. Common-Cause Failure Analysis
4. Data Uncertainty Analysis
5. QRVA Database Development

x. Event Sequence Quantification
1. Event Tree Split Fraction Quantification
2. Event Tree Quantification
3. Event Sequence Uncertainty Analysis

b. RHFSF Fuel Release from Internal Events QRVA (Level 2)
i. Probable Release Path Evaluation
ii. Event-Caused Structural Failure Evaluation
iii. Integration with Level 1 Risk Results

c. Risk Results Presentation and Interpretation

d. QRVA Vulnerability Assessment
i. Risk Decomposition (Risk by Initiating Event Category, Specific Initiating Events, Specific Event Sequences)

ii. Risk Importance Measure Determination and Evaluation for Event Tree Split Fractions and Fault Tree Basic Events
    1. Fractional Importance
    2. Risk Achievement Worth
    3. Risk Reduction Worth
    4. Fussell-Vesely Importance (Risk Participation Index)
    5. Birnbaum Importance (Risk Derivative)
iii. Risk Contribution Sensitivity Analysis
iv. Vulnerability Assessment Results Presentation and Interpretation

e. Internal Flooding QRVA
    i. Internal Flood Events Scope Determination
    ii. Internal Flood Facility Partitioning
    iii. Internal Flood Source Identification and Characterization
    iv. Internal Flood-Induced Initiating Event Analysis
    v. Internal Flood Scenario Development
    vi. Internal Flood Human Reliability Analysis
    vii. Internal Flood Accident Sequence Analysis
    viii. Internal Flood Data Analysis
    ix. Internal Flood Risk Quantification
    x. Internal Flood Risk Uncertainty Analysis
    xi. Risk Results Presentation and Interpretation
    xii. QRVA Vulnerability Assessment
        1. Risk Decomposition (Risk by Initiating Event Category, Specific Initiating Events, Specific Event Sequences)
        2. Risk Importance Measure Determination and Evaluation for Event Tree Split Fractions and Fault Tree Basic Events
            a. Fractional Importance
            b. Risk Achievement Worth
            c. Risk Reduction Worth
            d. Fussell-Vesely Importance (Risk Participation Index)
            e. Birnbaum Importance (Risk Derivative)
        3. Risk Contribution Sensitivity Analysis
        4. Vulnerability Assessment Results Presentation and Interpretation

f. Internal Fire QRVA (FQRVA
    i. Internal Fire Events Scope Determination
    ii. Facility Walk-Downs
    iii. FQRVA Database Development
    iv. Internal Fire Facility Partitioning
    v. FQRVA Component Selection
    vi. FQRVA Cable Selection
    vii. Internal Fire-Induced Initiating Event Analysis

viii. Internal Fire Scenario Development
ix. Internal Fire Human Reliability Analysis
x. Internal Fire Accident Sequence Analysis
xi. FQRVA Qualitative Screening
xii. Internal Fire Data Analysis
    1. Fire-Ignition Frequencies Development
    2. Equipment Fire Fragility Evaluation
    3. Fire Scenario Propagation Conditional Probability Development
    4. Fire Scenario Human Error Probability Evaluation
        a. Fire Scenario HEP Development
        b. Post-Fire Recovery Action HEP Development
xiii. Internal Fire Risk Quantification
    1. Quantitative Screening Phase 1
    2. Scoping Fire Modeling
    3. Quantitative Screening Phase 2
    4. Detailed Circuit Failure Analysis
    5. Circuit Failure Mode and Likelihood Analysis
    6. Detailed Fire Scenario Modeling (including Fire Phenomenology)
    7. Final Fire Risk Quantification
xiv. Internal Fire Risk Uncertainty Analysis
xv. Risk Results Presentation and Interpretation
xvi. QRVA Vulnerability Assessment
    1. Risk Decomposition (Risk by Initiating Event Category, Specific Initiating Events, Specific Event Sequences)
    2. Risk Importance Measure Determination and Evaluation for Event Tree Split Fractions and Fault Tree Basic Events
        a. Fractional Importance
        b. Risk Achievement Worth
        c. Risk Reduction Worth
        d. Fussell-Vesely Importance (Risk Participation Index)
        e. Birnbaum Importance (Risk Derivative)
    3. Risk Contribution Sensitivity Analysis
xvii. Vulnerability Assessment Results Presentation and Interpretation
xviii.

g. Seismic QRVA
    i. Develop Facility-Specific Seismic Risk Hazard Curves
    ii. Review Facility Safety Systems and Perform Initial Modification to Facility Internal Events QRVA System Models
    iii. Develop QRVA Seismic Equipment List
    iv. Conduct Facility Soil Failures Evaluation

v. Perform Seismic Response Analysis (Including Developing Floor Spectra and Structural Response Analyses)
vi. Perform Facility Walk-Downs for Seismic QRVA
vii. Screen Components from Internal Events QRVA Equipment List
viii. Perform Relay Chatter Evaluation
ix. Develop Seismic Fragility Parameters for Screened-In Equipment
x. Modify Internal Events QRVA Boolean Logic Models
xi. Seismic Events Human Reliability Analysis
xii. Seismic Events Accident Sequence Analysis
xiii. Seismic Events QRVA Data Analysis
xiv. Seismic Events Risk Quantification
xv. Seismic Events Risk Uncertainty Analysis
xvi. Risk Results Presentation and Interpretation
xvii. QRVA Vulnerability Assessment
    1. Risk Decomposition (Risk by Initiating Event Category, Specific Initiating Events, Specific Event Sequences)
    2. Risk Importance Measure Determination and Evaluation for Event Tree Split Fractions and Fault Tree Basic Events
        a. Fractional Importance
        b. Risk Achievement Worth
        c. Risk Reduction Worth
        d. Fussell-Vesely Importance (Risk Participation Index)
        e. Birnbaum Importance (Risk Derivative)
    3. Risk Contribution Sensitivity Analysis
xviii. Vulnerability Assessment Results Presentation and Interpretation

h. External Flooding QRVA (including tsunami and heavy precipitation)
i. External Flood Events Scope Determination
ii. External Flood Facility Partitioning
iii. External Flood Source Identification and Characterization
iv. External Flood-Induced Initiating Event Analysis
v. External Flood Scenario Development
vi. External Flood Human Reliability Analysis
vii. External Flood Accident Sequence Analysis
viii. External Flood Data Analysis
ix. External Flood Risk Quantification
x. External Flood Risk Uncertainty Analysis
xi. Risk Results Presentation and Interpretation
xii. QRVA Vulnerability Assessment
    1. Risk Decomposition (Risk by Initiating Event Category, Specific Initiating Events, Specific Event Sequences)

2. Risk Importance Measure Determination and Evaluation for Event Tree Split Fractions and Fault Tree Basic Events
    a. Fractional Importance
    b. Risk Achievement Worth
    c. Risk Reduction Worth
    d. Fussell-Vesely Importance (Risk Participation Index)
    e. Birnbaum Importance (Risk Derivative)
3. Risk Contribution Sensitivity Analysis

xiii. Vulnerability Assessment Results Presentation and Interpretation

i. External Fire QRVA
    i. External Fire Events Scope Determination
    ii. Facility Walk-Downs
    iii. FQRVA Database Development
    iv. External Fire Facility Partitioning
    v. FQRVA Component Selection
    vi. FQRVA Cable Selection
    vii. External Fire-Induced Initiating Event Analysis
    viii. External Fire Scenario Development
    ix. External Fire Human Reliability Analysis
    x. External Fire Accident Sequence Analysis
    xi. FQRVA Qualitative Screening
    xii. External Fire Data Analysis
        1. Fire-Ignition Frequencies Development
        2. Equipment Fire Fragility Evaluation
        3. Fire Scenario Propagation Conditional Probability Development
        4. Fire Scenario Human Error Probability Evaluation
            a. Fire Scenario HEP Development
            b. Post-Fire Recovery Action HEP Development
    xiii. External Fire Risk Quantification
        1. Quantitative Screening Phase 1
        2. Scoping Fire Modeling
        3. Quantitative Screening Phase 2
        4. Detailed Circuit Failure Analysis
        5. Circuit Failure Mode and Likelihood Analysis
        6. Detailed Fire Scenario Modeling (including Fire Phenomenology)
        7. Final Fire Risk Quantification
    xiv. External Fire Risk Uncertainty Analysis
    xv. Risk Results Presentation and Interpretation
    xvi. QRVA Vulnerability Assessment
        1. Risk Decomposition (Risk by Initiating Event Category, Specific Initiating Events, Specific Event Sequences)

2. Risk Importance Measure Determination and Evaluation for Event Tree Split Fractions and Fault Tree Basic Events
    a. Fractional Importance
    b. Risk Achievement Worth
    c. Risk Reduction Worth
    d. Fussell-Vesely Importance (Risk Participation Index)
    e. Birnbaum Importance (Risk Derivative)
3. Risk Contribution Sensitivity Analysis

xvii. Vulnerability Assessment Results Presentation and Interpretation

j. Other External Events QRVA
    i. High Winds and Storms (e.g., tornados, hurricanes, etc.)
    ii. Land Slides (including mud slides, sink holes, etc.)
    iii. Proximity Transportation Accidents (e.g., aircraft crash, external hazardous material spill or release, etc.)
    iv. Extreme Weather (e.g., high temperature, etc.)
    v. Other Facility-Specific Hazards
k. Environmental Transport and Consequence Analysis for Levels 3+ QRVA (Optional)
l. Risk Management Decision Support Metric Development and Analysis (Optional)

III. QRVA Proposed Work Breakdown Structure (WBS)
a. Proposed Project Phases
    i. Level 1 QRVA for Internal Events
    ii. Level 2 QRVA for Internal Events
    iii. Level 2 QRVA for Flooding and Fire
    iv. Level 2 QRVA for Seismic Events
    v. Level 2 QRVA for Other External Events
b. Proposed Task WBS
    i. Project Management
    ii. Project Quality Assurance
    iii. Meetings
    iv. QRVA Technical Tasks
    v. Final Report Documentation
    vi. Results Presentation(s)

IV. QRVA Project Management Considerations
V. QRVA Quality Assurance Considerations
a. ISO 9001 Quality Assurance
b. ASME/ANS Standard RA-S-2008 (with Current Addenda) Capability Categories
VI. QRVA Software Considerations
VII. References

Appendices

A. RHFSF Initial Information Item Request
B. RHFSF QRVA - Requested Navy Support Interfaces and Activities
C. Bibliography
D. Glossary
E. Acronyms