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Office of Civilian Radioactive Waste Management QA:N/A

PROCEDURE

HAZARDS ANALYSIS SYSTEM

AP-ESH-008

Revision 0, ICN 0

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Preparer(s):

B. Stewart
M. Taylor
R. Flye
M. Calcaterra

6/28/00
Date

Approval(s):

S. Mellington
Assistant Manager, Office of Project Execution

6/28/00
Date

CHANGE HISTORY

Revision Number	Interim Change No.	Effective Date	Description of Change
0	0	07/05/2000	Initial issue. Replaces PRO-SH-011, *Conducting a Job Safety Analysis*, and PRO-SH-012, *Conducting a Medical Needs Analysis*.

1.0 PURPOSE

The purpose of this procedure is to provide an integrated process for the conduct of systematic hazard analyses of current Yucca Mountain Site Characterization Project (YMP) design and work activities, using techniques commensurate with the complexity of the activity being analyzed, to facilitate application of controls to mitigate hazards to acceptable levels. The procedure outlines what analysis is required for each activity phase, when it is required, who performs the analysis, and how the analysis is categorized and used by the Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O). It describes organizational responsibilities and interrelationships of hazard analyses for operational safety of systems, structures, and components.

2.0 APPLICABILITY

This procedure applies to all Office of Civilian Radioactive Waste Management (OCRWM) employees, the CRWMS M&O, its subcontractors, the U.S. Geological Survey, and OCRWM direct support contractors. It is used to determine hazard analyses necessary to adequately assess the hazards of a job being planned while performing work in support of the OCRWM mission at facilities under OCRWM management and control. CRWMS M&O procedures, where referenced, are also applicable to the above organizations, except as specifically noted.

Activities described by this non-quality procedure are not subject to *Quality Assurance Requirements and Description*, DOE/RW-0333P, as this procedure merely overviews interfaces. Individual hazard analyses processes are controlled by independent Q and non-Q related procedures listed in Section 7.0.

3.0 DEFINITIONS

3.1 ***Acceptable Medical Assessment Level***–A summation of criteria that results in a score of 10 or higher as used to determine need for medical services support.

3.2 ***Accredited Industrial Hygiene Laboratory***–Laboratories accredited by the American Industrial Hygiene Association (AIHA) and are currently enrolled in appropriate Quality Assurance programs.

3.3 ***Contractor***–For the purpose of this procedure, the organizations, contractors and subcontractors referenced in Section 2.0.

3.4 ***ES&H Review***–An ES&H review of Work Package (WP) level work activity developed pursuant to the completion of an Operational Preliminary Hazard Analysis (OPHA) Checklist. The ES&H review, documented in the WP, identifies and evaluates hazards and addresses mitigating controls. Controls may include engineering, administrative or personal protective equipment, including reference to established procedures, processes and related requirements that assist in mitigating identified hazards.

3.5 ***Exposure Assessment***–The process of defining exposure profiles and judging the acceptability of workplace exposures to environmental and occupational stressors.

3.6 ***Exposure Profile***–Magnitude and variability of exposures for a Similar Exposure Group (SEG). This includes understanding of the central tendency of the exposures (such as mean exposures) and some understanding of the breadth, or variability, of the exposures (i.e., range of exposure) or frequency with which the exposures exceed the Occupational Exposure Limit (OEL).

3.7 ***Fire Hazard Analysis*** **(FHA)**–An analysis of the potential risks presented by fire hazards that could result in injury to employees or cause property damage. An FHA includes a relative risk analysis to determine if each fire risk is acceptable.

3.8 ***Hazard***–A condition or event that presents a potential foreseeable threat to personnel, equipment, or facilities.

3.9 ***Imminent Danger***–A condition or action creating a level of risk that can reasonably be expected to cause death or serious bodily harm if employees continue to be exposed.

3.10 ***Job Safety Analysis*** **(JSA)**–A structured, stepwise method to identify discrete tasks in a job, recognize the hazard(s) involved in each task, and specify mitigations to eliminate or reduce the hazard(s) to an acceptable level.

3.11 ***Job Step***–A logical segment of an operation or task where something is accomplished to advance the work.

3.12 ***Lessons Learned Database***–The Lotus Notes Lessons Learned database maintained by the M&O Lessons Learned Program Coordinator in accordance with AP-REG-001, *Managing Lessons Learned.*

3.13 ***Medical Assessment Level*** **(MAL)**–A summation of the three risk criteria (risk level, ambulance response time, and the working population being considered) that are used to make a Medical Needs Analysis (MNA).

3.14 ***Medical Needs Analysis*** **(MNA)**–An analysis to determine if field work may progress without close proximity medical care.

3.15 ***Occupational Exposure Assessment*** **(OEA)**–An Industrial Hygiene (IH) technique of systematic collection and analysis of occupational hazards and exposure determinants and linkage of the resulting exposure profiles of individuals and similarly exposed groups for the purposes of risk management and health surveillance.

3.16 ***Occupational Exposure Limit*** **(OEL)**–A generic term used to define maximum allowable airborne exposure limit. The legally enforceable exposure limits are the Occupational Safety and Health Administration's (OSHA's) permissible exposure limits. Other agencies, guidance, or professional organizations such as the American Conference of Governmental Industrial Hygienists or the National Institute for Occupational Safety and Health (NIOSH), have developed recommended airborne exposure limits. The M&O uses the most conservative limit.

3.17 ***Occupational Stressors***–Environmental stimuli that represent potential adverse impacts on the health of workers. Stresses may include physical and chemical agents as well as ergonomic stress.

3.18 ***Operational Preliminary Hazard Analysis*** **(OPHA)**–An analysis technique used in the conceptual stage of work to identify hazards, apply mitigations, quantify risk, and determine if task level hazard analysis should be performed based upon relative risk. (See Attachment 1, Conducting an Operational Preliminary Hazard Analysis.)

3.19 ***Personal Protective Equipment Hazard Assessment*** **(PPEHA)**–An analysis of personal protective equipment (PPE) selection based upon hazard.

3.20 ***Preliminary Hazard Analysis*** **(PHA)**–A process conducted by the System Safety Organization (Specialty Engineering) on a planned work activity, or early in a design's development, that identifies potential hazards that the activity or implementing the design may present.

3.21 ***Professional Judgment***–The capacity of an experienced professional to draw correct inferences from incomplete quantitative data, frequently on the basis of observations, analogy, and intuition (adopted from the AIHA).

3.22 ***Risk Level***–A qualitative evaluation of both the severity of an injury or illness and the probability the injury or illness will occur when all reasonable mitigating measures are in place.

3.23 ***Safety Basis***–The combination of information relating to the control of hazards at a facility (including design, engineering analyses, and administrative controls) upon which it can be concluded that activities at the facility can be conducted safely. The *Safety Basis Report* describes the industrial safety basis for the YMP Site Characterization activities.

3.24 ***Similar Exposure Group*** **(SEG)**–A group of employees who experience similar exposures to occupational stressors. They can be grouped by job classification, tasks, or similar substance exposure.

3.25 ***Site Disturbing Activity***–Any field activity that requires the deliberate movement of soil, fill, or rock by blasting or mechanized equipment within the Test Waste Isolation and Evaluation Zone, as described in the current version of the *Yucca Mountain Project Site Atlas*, YMP/88-21, or the use of tracers, fluids, or materials. Activities that use hand tools alone are not site disturbing for purposes of this definition.

3.26 ***System Safety Analysis*** **(SSA)**–Systematic process of evaluating and documenting system design-related hazards (YAP-30.48, *System Safety Analysis*).

3.27 ***Structures, Systems, or Components*** **(SSCs)**–For the purpose of this procedure, non-nuclear facility SSC whose preventative or mitigative function is a major contributor to defense in depth (i.e., prevention of uncontrolled hazardous material release) and/or worker safety.

3.28 ***Work Order*** **(WO)**–A document that defines the scope, identifies the processes and controls, hazard identification and mitigation, roles, responsibilities, and interfaces of individuals that are responsible for the execution of a unit of work. (Synonymous with Work Instruction.)

3.29 ***Work Package*** **(WP)**–For purposes of this procedure, any WP, Testing Field WP, Field WP, Laboratory WP, Work Plan, or Construction/Site Services and Maintenance Management WP used as a planning and implementing document for identifying responsibilities of interfacing organizations' roles and responsibilities for quality, or non-quality, site disturbing or non-site disturbing, field or non-field work.

4.0 RESPONSIBILITIES

4.1 The Assistant Manager, Office of Project Execution (AMOPE) is responsible for the preparation, change, and approval of this procedure.

4.2 The following M&O organizations or positions are responsible for activities identified in this Section and Section 5.0 of this procedure:

a) Director, Waste Management and Repository Facilities

b) Architectural/Engineering (A/E) and Field Engineering Managers/Supervisors

c) Specialty Engineering

d) Fire Protection Engineers

e) Manager, Site Construction and Operations

f) Director, Environment, Safety and Health (ES&H)

g) Managers/Supervisors, Project Engineers (PEs), Principal Investigators (PIs), and Affected Employees

h) Planner/Engineer

i) Safety and Health (S&H) Manager

j) Managers or Supervisors, PEs, PIs, work planners, Employees

k) Managers/Supervisors

l) M&O ES&H IH Lead

m) M&O Industrial Hygienist

4.3 General Responsibilities

4.3.1 AMOPE:

a) Ensure that project safety and health plans and hazard analyses are revised as necessary to address identified deficiencies in project safety and health performance or changes in project operations, contractors, or personnel.

b) Request and approve SSAs and FHAs as needed during new facility construction or major renovation.

c) Ensure that hazards analyses processes are accomplished by the affected parties to cover the hazards associated with the work and sufficient information for the selection of safety standards and controls.

d) Monitor and assess the effectiveness of DOE Contractors' hazard analysis process associated with work at their facilities.

4.3.2 Managers/Supervisors:

Ensure all employees tasked to conduct hazards analyses in accordance with this procedure are trained in the procedure's utilization.

5.0 PROCESS

Acronyms and abbreviations used in this procedure are defined in Attachment 2, Acronyms and Abbreviations. An overview of the Hazard Analysis System (HAS) is described and depicted in the flowchart in Attachment 3, Hazard Analysis System Flowchart.

PROCESS OUTLINE

5.1 DESIGN HAZARD ANALYSIS

5.1.1 SSAs and FHAs

5.1.1.1 Director, Waste Management and Repository Facilities:

a) Conduct a PHA on a designed system following the procedures in YAP-30.48 to determine if the designed systems have introduced hazards not previously analyzed.

NOTE: Analyses on Mined Geologic Repository nuclear safety-related systems, structures, or components (SSCs) are made by the Design Basis Event organization following appropriate U.S. Nuclear Regulatory Commission regulations to determine the credible Design Basis Events.

b) Determine the need for FHA development in accordance with DOE O 420.1, *Facility Safety*, DOE G 420.1-1, *Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide for use with DOE O 420.1,* Facility Safety, DOE O 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*, the Fire Safety Program, AP-ESH-004, *Occupational Safety and Health Program*, and the criteria in Attachment 4, Fire Hazard Analysis.

5.1.1.2 A/E and Field Engineering Managers/Supervisors:

a) Ensure SSAs for designed systems are conducted in accordance with YMP/94-13, *System Safety Plan*, YAP-30.48, and the criteria in Attachment 5 of that procedure.

b) Inform Fire Protection Engineers early in the planning stage of a proposed field design activity of an Exploratory Studies Facility (ESF) system, component, structure, or A/E baseline design.

c) Review the Lessons Learned Database for relevant information that can be incorporated or otherwise addressed in the SSA or FHA.

d) Determine if design will impact the Occupational Exposure Assessment (OEA) or the PPEHA, necessitating revision.

NOTE: Field Engineering develops design submittals and submits them to the A/E for review and approval in accordance with LP-OM-019-M&O, *Field Design Control.* The A/E reviews the submittal for technical content and coordinates the proposed field modification with M&O S&H and the Preclosure Safety Analysis Team. The A/E will prepare a Technical Change Request in accordance with AP-3.4Q, *Level 3 Change Control*, to incorporate field modifications from the approved submittal to the baseline documents. The Technical Change Request process will ensure that the new design is reviewed against the Technical Baseline and applicable SSAs and FHAs

NOTE: Contact the Director, ES&H, for assistance in determining design impacts on the current OEA or PPEHA.

e) Ensure FHAs for designed facilities are conducted in accordance with DOE O 420.1, DOE G 420.1-1, DOE O 440.1A, the Fire Safety Program, AP-ESH-004, and the criteria in Attachment 4.

f) A/E ensure final FHA recommendations entered into the Condition Identification and Reporting/Resolution System (CIRS) database are incorporated into design as appropriate and tracked to closure.

g) Ensure SSA hazard mitigations are incorporated into design as appropriate.

5.1.1.3 Specialty Engineering:

a) Conduct SSAs for designed systems in accordance with YMP/94-13, YAP-30.48, and Attachment 5, System Safety Analysis.

b) Review the Lessons Learned Database for relevant information that can be incorporated or otherwise addressed in the SSA or FHA.

c) Determine if design will impact the OEA or the PPEHA, necessitating revision.

NOTE: Contact the Director, ES&H, for assistance in determining design impacts on the current OEA or PPEHA.

d) Submit draft SSAs supporting construction designs to the Director, ES&H, for review and comment.

5.1.1.4 Fire Protection Engineers:

a) Obtain document identification for the FHA in accordance with AP 6.1Q, *Controlled Documents*.

b) Review the Lessons Learned database for applicable information that can be incorporated into the FHA.

c) Develop FHAs for designed facilities in accordance with DOE O 420.1, DOE G 420.1-1, DOE O 440.1A, the Fire Safety Program, AP-ESH-004, and the criteria in Attachment 4 of this procedure.

d) Submit draft FHAs to the U.S. Department of Energy (DOE) AMOPE, Director, ES&H, and A/E for review and approval.

e) Enter the final FHA recommendations into the CIRS database.

f) Review FHAs annually and submit a record of review to the AMOPE by March 1 each year, including budget estimates for facility modifications.

NOTE: If an FHA is completed before an associated SSA is finished, forward the FHA to Specialty Engineering for their determination if it can be incorporated into the SSA.

5.1.1.5. Manager, Site Construction & Operations:

a) Implement SSA hazard mitigations and FHA recommendations identified.

b) Comply with controls developed from hazard analyses.

c) Ensure that the design and the results of the SSA and the FHA are assessed for impact to the Safety Basis in accordance with AP-ENG-001, *Management of the Safety Basis Change Process.*

5.1.1.6. Director, ES&H:

a) Provide oversight to ensure SSAs and FHAs are developed and implemented in accordance with requirements for designed systems and facilities.

b) Review and comment on draft SSAs and FHAs, including annual FHA reviews.

c) Conduct baseline and subsequent reviews of OEAs and PPEHAs.

5.2 WP HAZARD ANALYSIS

5.2.1 OPHA

5.2.1.1 Managers/Supervisors, PEs, PIs, and Affected Employees:

a) Ensure that an OPHA is conducted and documented for all planned issuance of or revision to WPs. The OPHA will:

1) Describe or reference the scope of work for the WP.

2) Identify and list all potential occupational safety and IH health hazards involved with the work activity.

3) Determine impacts to the existing Safety Basis.

NOTE: Non-scientific or non-construction WPs involving physical work may require OPHAs. See Attachment 6, Conducting a Job Walk-Through, for additional information.

b) Consult with employees and ES&H personnel, as appropriate, for assistance in conducting the OPHA.

c) Review Lessons Learned database and incorporate applicable Lessons Learned into the WP.

d) Review the work process and identify hazards associated with the WP activity.

e) From the OPHA Checklist, prepare an ES&H Review that includes hazard analysis and control measures and document the ES&H Review in the WP.

1) Ensure all "yes" responses from the OPHA Checklist undergo the required additional hazard analysis and a determination of control measures for operations, processes, or activities that have the potential to cause overexposure, accident, injury, or illness.

NOTE: Control measures include, but are not limited to, engineering, administrative, and personal protective equipment, including implementation of controls established in procedures, existing JSAs, PPEHA, OEA, and MNA.

2) Screen for potential Safety Basis impact per Attachment 1, Blocks 5, 6, and 7.

f) Attach the OPHA Form to the WP.

g) Comply with control measures identified in the WP.

5.3 WO HAZARD ANALYSIS

5.3.1 Planner/Engineer

NOTE: The Planner is an M&O functional title used at the YMP ESF in Area 25. For purposes of this procedure, the title also applies to Test Coordination Office PEs and other individuals assigned to perform this role by Facility Managers.

a) Upon receipt of the work request, formulate potential/possible hazards known for the work required. Identify potential hazards from:

1) Previous personal experience with other, similar jobs

2) A previously planned job from which job hazards can be duplicated

3) Review of the appropriate OPHA developed for the WP

4) Review of the Lessons Learned database

5) Review of the applicable OEA and PPEHA

6) Research of applicable OCRWM Program Documents and Procedures

7) Reference and incorporation of existing applicable JSAs

8) Industry standards such as OSHA, National Electric Code, Uniform Building or Plumbing Code, etc.

9) Manufacturer's maintenance and reference manuals

10) A subject-matter expert e.g., carpenter foreman, electrical superintendent, craftsperson, etc.

11) Job Planner Job Walk-Through Checklist

b) Conduct a job walk-through to validate hazard identification.

1) When the work planner determines it is necessary, walk the job with the requestor, ES&H personnel, a subject-matter expert, or an additional planner/engineer for "another set of eyes" to identify potential hazards, using the work planner Job Walk-Through Checklist.

2) Survey, identify, and record the sources of the hazards to workers. Consideration should be given to the visibly obvious along with the basic hazard categories listed on the checklist (if used). Hazards recorded will be analyzed and controls established in the WO.

3) Organize and analyze data gathered from the walk-through. Envision the potential for injury by reviewing and determining the type and seriousness of potential injury from each of the hazards in an area. The possibility of simultaneous hazards should be considered.

c) After the potential hazards have been identified, provide mitigation steps as controls.

1) Analyze the data.

2) Break the job down into discrete job steps.

3) Scrutinize each step separately and provide mitigations for each hazard previously identified in that step.

4) Assign necessary actions needed to eliminate/reduce the hazards and write into the appropriate section of the WO. It is best to state the hazard and the mitigation together for each hazard; that is, do not list separate from each other.

5) Reference the document/publication that contains the mitigation in the WO. Attach the referenced documentation if economically feasible.

6) Subject WO to review in accordance with AP-OM-006, *Work Request/Work Order Process*.

5.4 JOB SAFETY ANALYSIS

5.4.1 S&H Manager:

a) Provide guidance, upon request, to individuals who are conducting JSAs.
b) Work with the JSA originator to resolve unacceptable JSAs.
c) Review and concur on draft JSAs.
d) Return approved JSAs to originator.
e) Ensure approved JSA are incorporated into the JSA database on Lotus Notes.

5.4.2 Managers or Supervisors, PEs, PIs, Work Planners, Employees:

a) Review jobs using the following criteria to determine if a JSA needs to be conducted:

1) When risks identified by an OPHA, an ES&H evaluation, or a job planning walk-through identify the need for more detailed task level analysis to identify the specific hazards and their potential effects

2) When tasks not previously performed on the YMP are planned

3) When a substantial change to ongoing operations, equipment, or a specific task, e.g., a change in work methods, is made or is going to be made

4) When it is determined for some reason, e.g., a series of accidents, that existing operations or procedures have not been adequately evaluated or need reevaluation

5) When new equipment is introduced that has different operating characteristics than equipment currently in use, e.g., a new make or model that has a different set of controls

6) Where indicated in an SSA, FHA, OPHA, or ES&H review that a JSA should be accomplished as a mitigation.

b) Conduct JSAs using the worksheet and method described Attachment 7, Conducting a Job Safety Analysis.

c) Coordinate with affected departments regarding the need for, and development of, any work procedure(s) derived from a JSA.

d) Forward draft JSAs to the S&H Manager for review and concurrence.

e) Incorporate JSA provisions and controls into WOs.

1) Implement actions described in new or revised task procedures that are developed as a result of the JSA.

2) Implement engineering, administrative, or personal protective equipment changes identified by the JSA before work begins or as promptly as possible for ongoing jobs.

f) Stop work (Time Out for Safety) when a newly identified hazard is recognized as an imminent danger until appropriate mitigation features are in place.

g) Review existing JSAs prior to subsequent use or following completion of a WO as indicated necessary through the work control feedback process to determine currency and update as necessary in accordance with the process in Attachment 7.

h) Promptly provide instructional dissemination to employees on the new/revised JSA, including procedures into which the JSAs are incorporated.

i) Ensure that affected employees participate in JSA development.

5.5 PERSONAL PROTECTIVE EQUIPMENT HAZARD ASSESSMENT

5.5.1 Managers/Supervisors:

a) Conduct hazard assessments of work area(s) with assistance participation from ES&H staff to ensure appropriate, approved PPE is selected in accordance with Attachment 8, Conducting a Personal Protective Equipment Hazard Assessment.

b) Inform ES&H when operational conditions or processes change so PPE may be modified to address current operating conditions.

c) Include the PPEHA process in the development of JSAs/WOs.

d) Ensure that personnel understand when and what PPE is required, wear PPE, and know the limitations of PPE, including the standards that require its usage.

5.5.2 S&H Manager:

Assist each operational area manager/supervisor in performing a hazard assessment of their work areas to ensure that appropriate PPE is selected.

5.5.3 M&O ES&H IH Lead:

Complete the PPEHA Form in accordance with Attachment 7 with assistance from either an area supervisor or by WO/JSA review.

5.6 OCCUPATIONAL EXPOSURE ASSESSMENT

5.6.1 Managers/Supervisors:

a) Conduct assessments, with assistance from ES&H, to identify operations having potential occupational exposure risks. (See Attachment 9, Conducting an Occupational Exposure Assessment.)

b) Provide workplace, workforce, and stressor information necessary to develop exposure and health ratings.

c) Notify ES&H of changes to operations that may impact exposure risk.

d) Coordinate, evaluate, and implement recommendations/controls to minimize employee exposure risks.

e) Utilize Integrated Safety Management (ISM) principles to plan work to involve affected workers in the planning of work activities.

5.6.2 S&H Manager:

a) Provide primary oversight and integration of the program.
b) Provide record keeping capabilities for OEAs.
c) Provide technical direction as appropriate.
d) Perform an annual assessment of the OEA program.

5.6.3 M&O Industrial Hygienist:

a) Assist Managers/Supervisors in conducting OEAs in accordance with Attachment 9.

b) Anticipate and evaluate potential chemical, physical, and biological hazards in the workplace.

NOTE: The use of the health hazard inventory may be a base document to initiate this process.

c) Identify SEGs.

d) Participate in the planning phase and utilize ISM principles for the planning of work activities.

e) Recommend hazard control strategies and document effectiveness of control strategy.

f) Perform required exposure monitoring as necessary.

g) Provide employees with sample results and an explanation of what the results mean.

h) Perform periodic (annual) sampling of operations to determine that the exposures remain below the OEL.

i) Maintain copies of all exposure assessment records and air monitoring results.

5.7 MNA

5.7.1 S&H Manager:

a) Develop and maintain the MNA process.
b) Interpret the process in the event questions of application are raised.

5.7.2 Managers/Supervisors:

a) Determine whether an analysis needs to be conducted based on the following conditions:

- Any physical work performed outside the Ranch Control area at any time

- For all remote field locations, inside or outside the Ranch Control area, for any manner of work on days when the Emergency Medical Technicians (EMTs) are not scheduled to be present in the Ranch Control area.

NOTE: See Attachment 10, Conducting a Medical Needs Analysis, for determination of remote activity.

b) Conduct the analysis using the method described in Attachment 10.

c) Document every analysis conducted using the MNA Worksheet, also in Attachment 10.

NOTE: An analysis need not be repeated for future work if the same set of job matrices exist for a job at the same location.

d) If the MAL is less than 10, reduce one or more of the matrix criteria to bring the assessment level over 10, delay the job until conditions can be established to obtain a MAL of 10 or higher, or cancel the job.

e) Maintain the MNA until the job is completed.

f) Forward the analysis to the M&O S&H Manager when the job is finished.

g) Include the MNA Worksheet form in the affected WO.

5.8 TRAINING

Training & Development Department provide employees tasked with hazard analysis training in the utilization of this procedure as directed by management.

6.0 RECORDS

The documents listed in Subsections 6.1 and 6.2 shall be collected and submitted to the Records Processing Center in accordance with AP-17.1Q, *Record Source Responsibilities for Inclusionary Records*, as individual records or included in a records package, as specified.

6.1 QA RECORDS

None

6.2 NON-QA INCLUSIONARY RECORDS

Individual Records:

FHA
SSA

Responsible persons submit copies of non-QA records required by procedures and other documents referenced herein to the Records Processing Center in accordance with those procedures.

6.3 NON-QA EXCLUSIONARY RECORDS

Responsible persons maintain exclusionary records in accordance with the procedures and other documents referenced herein. Additional records required by this procedure shall be maintained and dispositioned in accordance with the OCRWM Program Records Retention Schedule as follows:

JSA
OEA
OPHA
PPEHA
WO
WP
Work Planning Job Walk-Through Hazard Checklist

7.0 REFERENCES

a) 29 CFR 1910.133, Labor: Eye and Face Protection

b) 40 CFR 302.4, Protection of Environment: Designation of Hazardous Substances

c) DOE G 420.1-1, *Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide for use with DOE O 420.1,* Facility Safety

d) DOE O 420.1, *Facility Safety*

e) DOE O 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*

f) DOE O 5481.1B, *Safety Analysis and Review System*

g) *Quality Assurance Requirements and Description*, DOE/RW-0333P

h) AP-3.4Q, *Level 3 Change Control*

i) AP-3.11Q, *Technical Reports*

j) AP-3.13Q, *Design Control*

k) AP-5.2Q, *Testing Work Packages*

l) AP-6.1Q, *Controlled Documents*

m) AP-17.1Q, *Record Source Responsibilities for Inclusionary Records*

n) AP-ENG-001, *Management of the Safety Basis Change Process*

o) AP-ESH-004, *Occupational Safety and Health Program*

p) AP-OM-006, *Work Request/Work Order Process*

q) AP-REG-001, *Managing Lessons Learned*

r) LP-ESH-020-M&O, *Respiratory Protection*

s) LP-OM-019-M&O, *Field Design Control*

t) NLP-5-3, *YMP Site Construction Field Work Authorization Process*

u) YAP-30.42, *Submittals Control and Review*

v) YAP-30.48, *System Safety Analysis*

w) YMP/88-21, *Yucca Mountain Project Site Atlas*

x) YMP/94-13, *System Safety Plan*

y) PRO-SH-004, *Hearing Conservation Program*

z) FWP-ESF-96-009, Rev. 3, *Consolidated Sampling in the Exploratory Studies Facility (ESF)*

aa) MIL-STD-882C, *System Safety Program Requirements*

bb) *Safety Basis Report*

cc) *OCRWM Program Records Retention System*

dd) Electrical Safety Manual, BAB000000-01717-3500-00001

8.0 ATTACHMENTS

Attachments to this procedure are extensions of Section 5 requirements. Forms included with attachments are controlled and distributed as full-size documents separate from this procedure and may be copied for use when implementing this procedure.

Attachment 1 – Conducting an Operational Preliminary Hazard Analysis

Attachment 2 – Acronyms and Abbreviations

Attachment 3 – Hazard Analysis System Flowchart

Attachment 4 – Fire Hazard Analysis

Attachment 5 – System Safety Analysis

Attachment 6 – Conducting a Job Walk-Through

Attachment 7 – Conducting a Job Safety Analysis (Form AP-ESH-008.1)

Attachment 8 – Conducting a Personal Protective Equipment Hazard Assessment (Form AP-ESH-008.2)

Attachment 9 – Conducting an Occupational Exposure Assessment

Attachment 10 – Conducting a Medical Needs Analysis (Form AP-ESH-008.3)

Conducting an Operational Preliminary Hazard Analysis

An OPHA must be conducted on all WPs. The OPHA is conducted in three phases. First, planned work activities are reviewed to identify and list potential safety hazards. Second, all hazards identified are assigned controls to mitigate the hazards. Mitigating controls include engineering, administrative/work practice, or PPE controls.

Based on the defined scope of work contained in the Field Work Package (FWP), potential safety and health hazards shall be identified and mitigating controls developed. The line managers, supervisors, ES&H personnel and employees directly involved in the work and the potential hazards associated with it, shall conduct this hazard identification. To aid in identification of potential hazards, complete an OPHA Checklist and attach to each WP. Impacts on the Safety Basis shall be subjected to screening in accordance with Section 5.2 of AP-ENG-001.

Further analyze the hazards and document the hazard analysis as an ES&H Review in the WP. Hazard mitigation and control shall rely first on engineering controls, then administrative and work practice controls, with PPE only being used as a secondary line of defense. Provide this information in the WP.

Obtain ES&H concurrence with the ES&H Review. The OPHA Checklist shall also be attached to the WP and submitted to the Director, ES&H, for review and approval.

Operational Preliminary Hazard Analysis Checklist

Review the Hazard Identification Checklist and provide a "YES" or "NO" answer. The work/activity check list addresses potential hazards to personnel, property, or the environment. The Safety Basis checklist is used to determine impacts to existing systems.

1. WP/FWP/Laboratory Work Package (LWP) Title and Number:
2. Date of Analysis:

3. Scope of Work Description:

4. Will the work involve any of the following activities?

Work Activity	Yes	No
Trenching/ Excavation		
Geophysical Investigation		
Subsurface Construction		
Surface Construction		
Dry Drilling		
Wet Drilling		
Modification to existing structures		
Sample Collection		
Decontamination		
Work outside in inclement weather		
Exposure to temperature extremes		
Work on off-normal hours or in remote locations		
Maintenance activities		
Operational activities		
Heavy Equipment		
Lasers or Laser systems		
Material/soil containing Crystalline Silica		
Radioactive materials/logging tools		
Biological hazards		
Utility/Electrical Modifications		
Exposure to high noise levels		
Confined Space entry & work		
Equipment with exposed mechanical/moving parts		
Working at a height greater than 6 ft		
Welding, cutting, brazing		
Working on uneven, slippery surfaces		
Use of any chemical that is Flammable/Ignitable, Corrosive, Reactive or Toxic		
Fire or explosive hazards		
Generation, storage of Hazardous and Non-Hazardous Waste(s)		
Work with Explosives (Blasting)		
Impacts to external Organizations/Facilities		

5. Will the work impact any of the following YMP Systems?

Safety Basis System	Yes	No
Compressed Air (FCL2)		
Other: Hazardous Material Inventory		
6. Is the activity adding a system that has not been developed through the design process (A/E or Field Design)?		

(FCL1) = Functional Classification Level 1(FCL2) = Functional Classification Level 2
(FCL3) = Functional Classification Level 3
(FCL4) = Functional Classification Level 4

7. All "Yes" responses in block 5 require additional documented hazard analysis and mitigating control development. A "Yes" response in block 6 requires the proposed activity to be subjected to the Section 5.2 screening process of AP-ENG-001.

8. Manager/Supervisor Signature:

Date:

INSTRUCTIONS FOR COMPLETION OF OPHA CHECKLIST

1. Provide the name, title and number of the FWP, LWP, or Work Plan for which the PHA is being conducted. (i.e., FWP-ESF-96-009, Rev 3, Consolidated Sampling in the Exploratory Studies Facility (ESF)).

2. Provide a description of the planned work. Describe the location, operation, activity, or process, and the type of equipment that is planned to be used.

3. Review the WP planned work activity. Provide a "Yes" or "No" response to each question in Block 5 regarding anticipated work activities.

4. In order to facilitate completion of the form a brief explanation of the terms describing Work Activities is provided below:

   - Trenching/Excavation: The term trenching and excavation would apply to any ground disturbing activity that is more than 5 ft in depth. Most trenching and excavation usually involves the use of heavy equipment (backhoe, shovel, front end loader). The term trenching and excavation would include scientific characterization test pits, construction of underground utilities (electrical power, sanitary sewer, drinking water, etc).

   - Geophysical Investigation: The term geophysical investigation would involve any type of scientific characterization activity that would gather geologic data and information. Such activities would include but not be limited to geologic mapping, detail line surveys, borehole packer installation and operation, borehole tracer gas injection, permeability experiments, etc.

   - Subsurface Construction: The term subsurface construction would apply to any underground construction activity, including the construction of underground testing alcoves and niches. Subsurface construction would include the operation of a Tunnel Boring Machine, Alpine or Dasco Continuous Mining Machine, or underground construction involving drill and blast methods.

   - Surface Construction: The term surface construction would apply to any new surface based construction. Surface Construction would include set-up and installation of mobile office structures, storage tents, and more permanent structures such as the change house. In addition the term surface construction would apply to the construction of infra-structure systems, such as electrical power distribution systems, sanitary sewer and other utilities.

   - Dry Drilling: The term dry drilling would apply to any surface or subsurface drilling activity where a mixture of fine cuttings from the mechanical drilling process and compressed air is used as the drilling fluid.

   - Wet Drilling: The term wet drilling would apply to any surface or subsurface drilling activity where a mixture of fine cuttings from the mechanical drilling process and water is used as the drilling fluid.

   - Modification to existing structures: The term modification to existing structures means any change to the structural, mechanical, electrical, or heating and air conditioning system of an existing YMP structure or building.

   - Sample Collection: The term sample collection refers to the collection of geologic samples for scientific investigations, Determination of Importance Evaluations, collection of water samples, and does not include samples collected for safety and health or IH purposes.

- Decontamination: The term decontamination refers to the removal or clean-up of chemical substances or biological agents.

- Work outside in inclement weather: The term work outside in inclement weather refers to outside work involving exposure to sun, wind, rain, snow, sandstorms, lighting strikes, extremes in hot and cold temperature, and working in environments with high humidity.

- Exposure to temperature extremes: Exposure to temperature extremes refers to exposure to extremely cold and hot environments (below 32 degrees F and above 100 degrees F).

- Off-normal hours: The term work off-normal hours refers to working hours when Ranch Control is not in operation.

- Remote location: As used in conducting an MNA, remoteness is established by evaluating the combination of the risk level of the planned work activity, the number of persons involved and the response time in minutes for emergency medical personnel (see Attachment 10 Procedure Matrix).

- Maintenance activities: The term maintenance activities refers to routine scheduled activities that are performed by skilled craft personnel conducting activities to written work instructions, or WOs. Maintenance activities would include but not be limited to servicing of air conditioning systems, cleaning, and housekeeping activities.

- Operational activities: The term operational activities refers to work in support of an FWP, LWP, WP, or construction or scientific characterization investigation.

- Heavy Equipment: The term heavy equipment refers to construction equipment such as earth moving equipment (back hoe, front end loader) Alpine or Dasco continuous mining equipment. Heavy Equipment also refers to any equipment that must be operated by skilled craft personnel such as operating engineers.

- Lasers or Laser systems: Laser or Laser systems refers to any American National Standards Institute Classified Class 1, Class 2, Class 3a, Class 3b, or Class 4 Laser or Laser System.

- Material/soil containing Crystalline Silica: The term materials containing Crystalline Silica refers to the chemical make-up of volcanic tuff with in Yucca Mountain.

- Radioactive materials/logging tools: The term radioactive materials /logging tools refers to any material that is radioactive or emits radiation. Logging tools use radioactive sources such as Neutron Sources.

- Biological Hazards: The term biological hazard refers to any blood born pathogens or environmental biological hazard such as Hanatvirus.

- Utility/Electrical Modifications: The term utility/electrical modification refers to modifications to existing sanitary sewer, electrical power, water, compressed air, ventilation, heat/cooling system.

- Exposure to High Noise Levels: The term exposure to high noise levels to refers to any noise source that generated more that 85dBA.

- Confined Space entry and work: The term confined space entry and work refers to any activity inside a space that is not designed to continuous human occupancy, that has only one entrance or exit, or that has an atmosphere that is oxygen deficient, or an atmosphere

containing vapors, fumes, dust, aerosols, or mists, or that contains an atmosphere that is explosive or could become explosive.

- Equipment with exposed mechanical/moving parts: The term equipment with exposed mechanical/moving parts refers to un-guarded equipment with rotating gears or mechanisms.

- Working at a height greater than 6 ft: The term working at a height greater that 6 ft refers to conducting construction or scientific characterization activities at a height 6 ft or greater from the ground.

- Welding, cutting, brazing: The term welding, cutting or brazing refers to stick or tig electric welding, cutting, or brazing metal with an oxygen and acetylene torch.

- Working on uneven, slippery surfaces: This terms refers to working on rocks, gravel or dirt, or working on any platform or surface that when wet is slippery.

- Use of any chemical that is Flammable/Ignitable, Corrosive, Reactive or Toxic: This terms refers to any chemical substance that has ingredients that are listed on the container label that include any of the above substances.

- Fire or explosive hazards: This term refers to any operation, or activity that has the potential to produce a fire or explosion if the proper control measure are not employed, such activities would include, but are not limited to fueling operations, welding, cutting, or brazing operations.

- Generation, storage of Hazardous and Non-Hazardous Waste: This terms refers to the storage of any waste material or chemical that is considered flammable, corrosive, reactive, or toxic.

- Working with Explosives: This term refers to work with type of explosive or blasting agents such as dynamite or ammonia based explosive, blasting, caps or detonators.

5. All "Yes" responses require additional documented Hazard Analysis. Attach the OPHA to the FWP or LWP.

   The responsible manager/supervisor must sign completed PHA Form and retain copy for in-house files. All "Yes" responses to the Safety Basis System require screening in accordance with Section 5.2 of AP-ENG-001.

6. Distribute the WP to affected organizations and employees.

7. The responsible manager/supervisor must sign the completed OPHA form and maintain with the WP in accordance with Section 7.0 of this procedure.

AC	Administrative Control
A/E	Architect/Engineer
AIHA	American Industrial Hygiene Association
AMOPE	Assistant Manager, Office of Project Execution
CIRS	Condition Identification and Reporting/Resolution System
CRWMS	Civilian Radioactive Waste Management System
DOE	U.S. Department of Energy
EMT	Emergency Medical Technician
ER	exposure rating
ES&H	Environment, Safety and Health
ESF	Exploratory Studies Facility
FHA	Fire Hazard Analysis
FWP	Field Work Package
HAS	Hazards Analysis System
HR	health effect rating
IH	Industrial Hygiene
ISM	Integrated Safety Management
JSA	Job Safety Analysis
LWP	Laboratory Work Package
M&O	Management and Operating Contractor
MAL	Medical Assessment Level
MNA	Medical Needs Assessment
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
OCRWM	Office of Civilian Radioactive Waste Management
OEA	Occupational Exposure Assessment
OEL	Occupational Exposure Limit
OPHA	Occupational Preliminary Hazards Analysis
OSHA	Occupational Safety and Health Administration
PE	Project Engineer
PEL	Permissible Exposure Limit
PHA	Preliminary Hazards Analysis
PI	Project Investigator
PPE	personal protective equipment
PPEHA	Personal Protective Equipment Hazard Assessment

S&H	Safety and Health
SAR	Safety Analysis Report
SE	Standard Error
SEG	Similar Exposure Group
SSA	System Safety Analysis
SSC	structure, system, or component
STEL	Short-Term Exposure Limits
TLV	Threshold Limit Value
WO	Work Order
WP	Work Package
YMP	Yucca Mountain Site Characterization Project

Hazard Analysis System Flowchart

Work planning and control is addressed by AP-SC-001, *Work Planning and Control*, AP-OM-006, and other subordinate procedures referenced in Section 7.0. To support this process, a graded approach for hazard analysis is required.. The Hazards Analysis System (HAS) is a process that reviews activities in all phases of the YMP's present industrial configuration (e.g., Design, WP, and WO). The purpose of the HAS is to provide systematic identification of hazards for all YMP activities, using hazard analysis techniques commensurate with the complexity of the activity under review, and controls to mitigate those hazards. As one of the five core functions of ISM, the systematic identification of hazards is a crucial step in ensuring the safe performance of work. In addition to providing input to the Design process, the budget and work planning processes and the work order development process, the HAS will provide the basis for determining if a proposed activity will impact the Safety Basis. The output of the HAS will serve as an input to AP-ENG-001, which describes the process by which the proposed activities will be evaluated to determine if a change to the Safety Basis is required and, therefore, if DOE approval of the proposed activity is required.

The HAS divides work into three main phases: design, WP, and WO. Design activities are subject to OCRWM AP-3.13Q, *Design Control,* and design hazard analysis is supported by SSA in accordance with YMP/94-13 and YAP 30.48. SSA techniques for SSCs employ risk assessment methodology in accordance with DOE Order 5481.1B, *Safety Analysis and Review System*, and MIL-STD-882C, *System Safety Program Requirements.* Designed facilities are subject to FHA in accordance with AP-ESH-004, DOE O 420.1, DOE G 420.1-1, DOE 440.1A, and the Fire Safety Program. Criteria for the conduct of SSAs or FHAs are contained in Attachments 4 and 5.

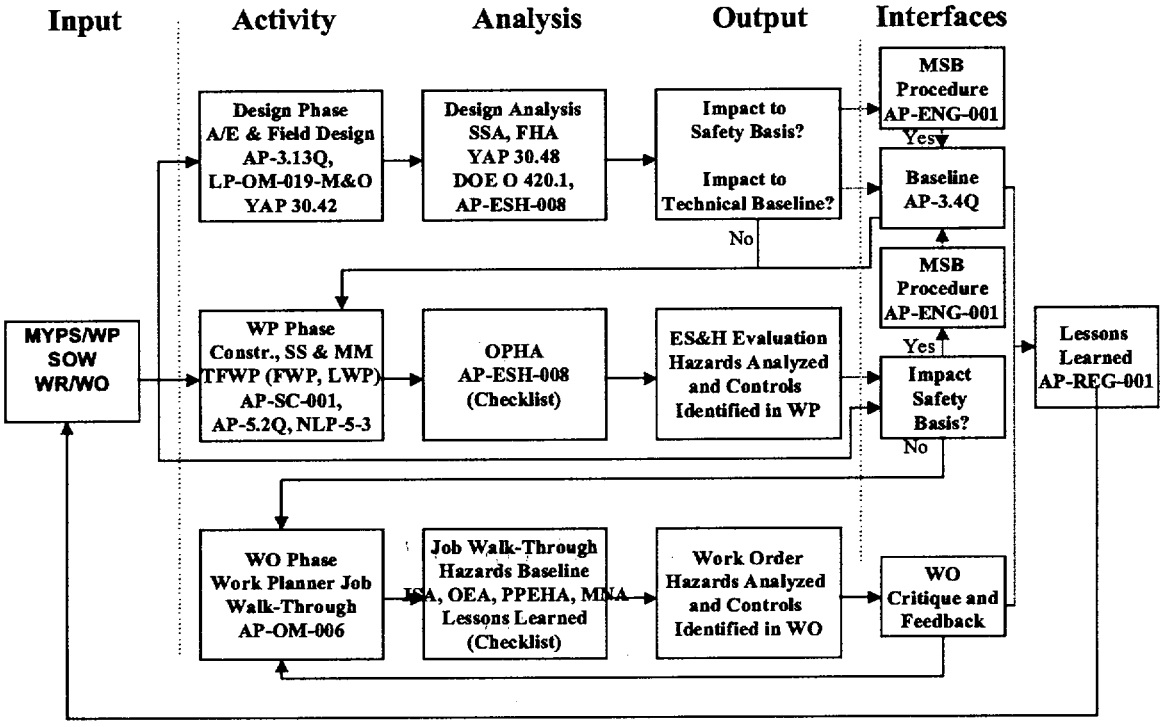
OPHAs (see Attachment 1) support the WP phase. Existing JSAs may also be referenced at the WP phase. The PHA identifies impacts to the existing Safety Basis and lists potential physical, chemical, and other hazards associated with performing the work. Hazards and their controls are identified in the OPHA and documented in an ES&H evaluation that is part of the WP. Responsibilities for the controls are also identified in the ES&H evaluation.

The WO phase is supported by physical walk-through (see Attachment 6) of the workplace by work planners. Work planners also review applicable procedures, JSAs, and other control documents in the work planning process.

Work planners may utilize checklists during the walk-through to assess the potential hazards and determine the safety impacts. OEA and PPEHA also support the HAS at the WP level and WO phase and require review by work planners. Criteria for conduct of a PPEHA and OEA are contained in Attachments 8 and 9 respectively.

Attachment 10 of this procedure establishes when and how an MNA is conducted to determine if field work may progress without close proximity medical care. This additional information is incorporated into the WO.

Hazards Analysis System Flowchart



Attachment 3 – Hazard Analysis System Flowchart (Continued)

Fire Hazard Analysis

DOE Order 420.1, Section 4.2.1.4, requires that an FHA be performed for all nuclear facilities, significant new facilities and facilities that represent unique and significant fire safety risk. The FHA shall be developed using a graded approach. The conclusions of the FHA shall be integrated into the design basis accident condition.

The YMP will conduct an FHA for:

- All major designed facilities/structures constructed at the site such as the Change House Facility, Electrical Switchgear Building, Underground ESF, etc.
- Small-occupied structures, e.g., shops, trailers, storage areas, and systems, included in an FHA
- For other facilities/structures as directed by the DOE AMOPE.

The format for the development of a FHA shall be in accordance with AP-3.11Q, *Technical Reports*. Significant changes or additions to structures or systems will require an update to the FHA. The FHA is reviewed for currency and updated as appropriate on an annual basis.

Preliminary FHAs are performed for all significant new facilities early in the design phase to ensure that an acceptable level of protection is being incorporated in the evolving design. It should be updated when significant changes occur within an individual fire area and should form the basis for the post-construction facility FHA.

The purpose of the FHA is to comprehensively and qualitatively evaluate the risk from fire within individual fire areas in a DOE facility so as to ascertain whether the DOE fire safety objectives identified in DOE O 420.1, DOE O 440.1A, and DOE G 420.1-1 are met. This must include an assessment of the risk from fire and related hazards (direct flame impingement, hot gases, smoke migration, fire-fighting water damage, etc.) in relation to existing or proposed fire safety features to ensure that the facility can be safely controlled and stabilized during and after a fire. In accordance with the "graded approach" concept, the level of detail necessary for an acceptable FHA is directly related to the complexity of the facility and the potential risk to the public and facility operators. The scope and content of an FHA should be limited to only those issues that are relevant to the facility or system.

An FHA should be performed under the direction of a qualified fire protection engineer, with support from systems, electrical, and mechanical engineers, as well as operations staff, as needed. An FHA shall contain, but not be limited to, a detailed assessment of the following fire safety issues:

- Description of construction
- Description of critical process equipment
- Description of high-value property
- Description of fire hazards
- Description of operations

- Potential for a toxic, biological, and/or radiation incident due to a fire
- Natural hazards (earthquake, flood, and wind) impact on fire safety
- Damage potential: Maximum Possible Fire Loss
- Fire protection features
- Protection of essential safety class systems
- Life safety considerations
- Emergency planning
- Fire Department/Brigade response
- Recovery potential
- Security and Safeguards considerations related to fire protection
- Exposure fire potential and the potential for fire spread between two fire areas
- Effect of significant fire safety deficiencies on fire risk
- Estimated replacement cost of all structures and systems.

The FHA should assume and evaluate the consequences of a single, worst-case automatic fire protection system malfunction. This could be a detection system that also functions to activate a pre-action type sprinkler system.

The FHA shall include recommendations for compliance of "as-constructed" to National Fire Protection Association (NFPA) codes, OSHA requirements, and the M&O S&H plans. These recommendations shall be recorded into the CIRS database as stated in Section 5.1.1.4.e. Upon closure of recommendations, the FHA shall be updated.

System Safety Analysis

In accordance with YAP/30.48, hazards and associated risks are managed through a systematic approach that begins with a PHA and ends with a final activity defined as "Hazard Mitigation and Control." The end result is a formal SSA document, which includes Scenario Analysis Summary sheets (see YAP/30.48 for complete process requirements).

PROCESS

The SSA process consists of the following principle activities, each of which is described in this attachment:

1) PHA
2) SSA
3) HAZARD MITIGATION AND CONTROL

PHA

The PHA is performed to identify hazards for further analysis in the SSA. The PHA may utilize any of the methodologies described in the SSA Handbook. The PHA addresses both external and internal events that could, under certain conditions, result in personnel safety or health hazards. For external events, a list of applicable hazards is generated from the PHA by applying a checklist of potential generic events and phenomena to the ESF/repository design in general. For internal events, a list of applicable hazards is generated from the PHA by applying a checklist of potential generic events to each functional area within the ESF/repository, as applicable. The PHA provides input to SSAs for non-radiological hazards and Design Basis Event analyses for radiological hazards. The PHA applies only to the preclosure time period.

SSA

SSAs are performed to identify safety critical SSCs and processes, potentially hazardous designs, operations and maintenance activities, and interfaces, including the human as part of the system. These analyses diagnose potential hazards and mishaps, their causative factors (also called hazard causes or risk factors), and recommend appropriate mitigation/control features. The SSA process utilizes the PHA results to identify scenarios. The results of the analysis, including documentation of recommended mitigation features, are documented on Scenario Analysis Summary sheets. When a Scenario Analysis Summary is completed and approved for each applicable hazard, the SSA is complete.

SSAs are generally triggered by design activities involving the following:

- SSCs supporting Category I or II Functional Classifications as contained in the *Safety Basis Report.*
- SSCs or equipment procured or manufactured including modification thereof, to no known consensus standard.

- SSCs susceptible to significant property damage (>$2.5 million) from known phenomenon.
- SSCs that are designed to manufacture, utilize or store hazardous materials in excess of the Reportable Quantities addressed by 40 CFR 302.4, Protection of Environment: Designation of Hazardous Substances
- Revision to an existing design supported by an SSA.
- As directed by the DOE.

HAZARD MITIGATION AND CONTROL

The purpose of the mitigation activity is to implement those specific measures that must be taken to prevent or mitigate potential hazards that have been identified through the system safety analysis process to reduce risk to an acceptable level. Once that risk level is achieved, no additional mitigations are required. However, additional safety activities or mitigation features may be implemented as part of a defense in depth concept and/or may be required by other regulatory agencies such as OSHA.

HAZARD CONTROL CRITERIA

The following general principles are used to prevent, mitigate or control hazards:

- Identified hazards will be eliminated or controlled, preferably by design (e.g., material selection or substitution).
- Hazardous substances, components, and operations will be isolated from other activities, areas, personnel, and incompatible materials by means of containment, operational shields, remote operations, and ventilation controls.
- Equipment access will be designed so that personnel exposure during operations, servicing, maintenance or repair to hazardous chemicals, high voltage, electromagnetic radiation, cutting edges, sharp points, and other hazards will be reduced to levels required by applicable regulations, guides and specifications, and accepted design practices.
- Hazards resulting from exposures such as temperature, pressure, noise, toxic substances, and vibration will be reduced to levels required by applicable regulations, guides and specifications, and accepted design practices.
- Designs will reduce opportunities for human error and human injury/death during operation, maintenance and other support activities.
- Whenever feasible, designs will include process monitoring to provide warnings of precursor conditions that could lead to a mishap.

Conducting a Job Walk-Through

The checklist provided below is used by work planners in identifying hazards associated with performance of work tasks. The work planner completes the checklist during a physical walk-through of the work location in the planning process. The checklist is a task level analysis.

Once the walk-through has been completed and potential hazards identified, the work planner provides additional analysis of the hazards and identifies mitigating controls in the WO. Most task level hazards are mitigated through existing procedures, safety rules, OSHA and DOE requirements, or JSA. If the task involves hazards not previously subjected to JSA and meets the criteria of Attachment 7, the work planner coordinates with management/supervision, ES&H and affected employees to ensure a JSA is developed.

WORK PLANNING JOB WALK-THROUGH HAZARD CHECKLIST				
INSTRUCTIONS: "X" THE "YES" COLUMN IF A POTENTIAL HAZARD EXISTS				
NO.	ITEM	YES	NO	INSPECTOR'S COMMENTS
	ACCELERATION/DECELERATION/GRAVITY			
1	Falling Objects			
2	Falls			
3	Fragments/Missiles			
4	Impacts			
5	Inadvertent Motion			
6	Loose Objects			
7	Slip/Trip			
8	Sloshing Liquids			
	CHEMICAL AND WATER CONTAMINATION			
9	Backflow/Siphon Effect			
10	Leaks/Spills			
11	System Cross-Connection			
12	Vessel/Pipe/Conduit Rupture			
	CONSTRUCTION			
13	Alpine Miner			
14	Ariel Lifts			
15	Concurrent Operations			
16	Confined Space			
17	Control of Hazardous Energy			
18	Crane operations, overhead or mobile			
19	Equipment operation near power utility poles/lines, or near structures or obstructions			
20	Excavations			
21	Forklifts			
22	Front-end Loaders			
23	Hydraulic			
24	Ingress/Egress			
25	Ladders			
26	Load Haul Dump			
27	Mechanized Equipment			
28	Mobile/heavy equipment safety			
29	Penetrations into walls, floors, etc.			
30	Scaffolds			
31	Scissors Lift			
32	Trenching/Shoring			
33	Trucks			
34	Walking/Working Surfaces			
	CONTINGENCIES			
35	Emergency responses to unusual events			
36	Accountability of personnel during evacuation			
37	"Hard" Shutdowns/Failures			
38	Earthquake			

CONTINGENCIES (Continued)				
39	Fire			
40	Flooding			
41	Hailstorm			
42	Outages of the plant public address			
43	Snow/Ice Load			
44	Utility Outages			
45	Windstorm			
CONTROL SYSTEMS				
46	Grounding Failure			
47	Inadvertent Activation			
48	Interference (Electromagnetic/Electrostatic)			
49	Lightning Strike			
50	Moisture			
ELECTRICAL				
51	Burns			
52	Distribution Backfeed			
53	Explosion/Electrical (Arc)			
54	Explosion/Electrical (Electrostatic)			
55	Grounding of electrical equipment			
56	Ignition of Combustibles			
57	Inadvertent Activation			
58	Overheating			
59	Power-actuated tools			
60	Power Outage			
61	Shock			
62	Unsafe–Failure to Operate			
ERGONOMIC				
63	Faulty Workstation Design			
64	Faulty/Inadequate Control/Readout Labeling			
65	Glare			
66	Inaccessibility			
67	Inadequate/Improper Illumination			
68	Inappropriate Control/Readout Location			
69	Nonexistent/Inadequate "Kill" Switches			
EXPLOSIVES				
70	Blast Overpressure			
71	Electrostatic Discharge			
72	Exudation			
73	Friction			
74	Heat			
75	Impact/Shock			
76	Lightning			
77	Mass Fire			
78	Seismic Ground Wave			
79	Thrown Fragments			
80	Transporting Hazardous Materials			
81	Vibration			
82	Welding (Stray Current/Sparks)			

FIRE/FLAMMABILITY				
83	Fuel			
84	Ignition Source			
85	Need for Fire Extinguishers or other fire protection measures			
HUMAN FACTORS				
86	Inadvertent Operation			
87	Operation Early/Late			
88	Operation Out of Sequence			
89	Operator Error			
90	Right Operation/Wrong Control			
LOCKOUT/TAGOUT				
91	Chemical			
92	Electrical			
93	Mechanical (steam, hydraulic, pneumatic, drains)			
MATERIAL CONDITION				
94	Asphyxiating			
95	Corrosive			
96	Dusts-Irritating			
97	Gases/Vapors			
98	Liquids/Cryogens			
99	Odorous			
100	Radiation Sources			
101	Reactive			
102	Toxic			
103	Transporting Hazardous Materials			
104	Vapor Propagation			
MECHANICAL				
105	Crushing Surfaces			
106	Ejected Parts/Fragments			
107	Lifting/balancing Weights			
108	Machine guards			
109	Pinch Points			
110	Reciprocating Equipment			
111	Rotating Equipment			
112	Sharp Edges/Points			
113	Stability/Topping Potential			
MISSION				
114	Activation			
115	Calibration			
116	Coupling/Uncoupling			
117	Diagnosis/Trouble Shooting			
118	Emergency Shutdown			
119	Emergency Start			
120	Load Change			
121	Shake Down			
122	Standard Shutdown			

	MISSION (Continued)			
123	Standard Start			
124	Stressed Operation			
125	Transporting Oversized Loads			
	OTHER			
126	Ability to hear public address, Emergency Notification System, or Criticality Accident Alarm System			
127	Ability to summon emergency response during emergencies			
128	Blockages/obstructions (Identify)			
129	Burning, welding, hot-work (permit)			
130	Compressed gas cylinders			
131	Critical lifts (heavy or high value loads)			
132	Elevated work/fall protection			
133	Emergency eyewash/shower available			
134	Faulty Calibration			
135	Fire protection system/equipment outage			
136	Flammable liquids/gases			
137	Hazards due to condition of facility or terrain			
138	Hoisting and rigging			
139	Seismic Disturbance/Impact			
140	Single-Operator Coupling			
141	Vermin/Varmints/Insects			
142	Vibration			
143	Wear-Out			
	PHYSIOLOGICAL			
144	Allergens			
145	Asphyxiants			
146	Carcinogens			
147	Cryogens			
148	Fatigue			
149	Irritants			
150	MNA			
151	Mutagens			
152	Noise			
153	Nuisance Dusts/Odors			
154	Pathogens			
155	Pressure Extremes			
156	Radiation (See Radiation)			
157	Temperature Extremes			
158	Teratogens			
159	Toxins			
160	Vibration (Raynaud's Syndrome)			
	PNEUMATIC/HYDRAULIC PRESSURE			
161	Backflow			
162	Blown Objects			
163	Crossflow			

PNEUMATIC/HYDRAULIC PRESSURE (Continued)				
164	Dynamic Pressure Loading			
165	Hydraulic Ram			
166	Implosion			
167	Inadvertent Release			
168	Mis-calibrated Relief Device			
169	Mis-located Relief Device			
170	Over-pressurization			
171	Pipe/Hose Whip			
172	Pipe/Vessel/Duct Rupture			
173	Relief Pressure Improperly Set			
RADIATION				
174	Alpha			
175	Beta			
176	Infrared			
177	Ionizing			
178	Laser			
179	Microwave			
180	Non-ionizing			
181	Radon			
TEMPERATURE EXTREMES				
182	Altered Structural Properties (e.g., Embrittlement)			
183	Confined Gas/Liquid			
184	Elevated Flammability			
185	Elevated Reactivity			
186	Elevated Volatility			
187	Freezing			
188	Heat Source/Sink			
189	Hot/Cold Surface			
190	Humidity/Moisture			
191	Pressure Elevation			
192	Reduced Reliability			
UNANNOUNCED UTILITY OUTAGES				
193	Air Conditioning			
194	Compressed Air/Gas			
195	Drains/Sumps			
196	Electricity			
197	Exhaust			
198	Fuel			
199	Heating/Cooling			
200	Lubrication			
201	Steam			
202	Ventilation			
MODIFIES SAFETY BASIS				
NOTE: A "yes" response in Blocks 203, 204, or 205 requires the proposed activity to be subjected to the Section 5.2 Screening Process of AP-ENG-001.				
203	Modify Compressed Air System			
204	Change Hazardous Material Inventory			
205	Is the activity adding a system that has not been developed through the design process (A/E or Field)?			

Conducting a Job Safety Analysis

A JSA is conducted in three parts:

- The job is broken down into discrete job steps.
- Each step is analyzed separately to identify potential injury or illness hazards that can be realistically expected to occur in the performance of that step.
- The necessary actions needed to eliminate/reduce the hazards are identified.

Prepare a worksheet in tabular form listing the proper sequence of steps in the task, their corresponding hazards, and the mitigations. When the worksheet is finished, it is reviewed for accuracy, completeness, and that the mitigations are practical and cost-effective.

NOTE: The JSA worksheet in this Attachment is available in the Automated Forms System database. Guidance on properly conducting the analysis follows.

A job, or operation, selected for analysis must first be examined for appropriate scope. If more than one discrete job is involved, consideration should be given to breaking each into a separate analysis. The classic examples used to illustrate jobs too broad or too narrow are "maintenance mechanic," which is too broad. The multiple tasks performed by this person should be analyzed separately. On the other hand, a task can be broken down too far, such as "tightening a screw," which is too narrow in scope to be functional as a stand-alone analysis.

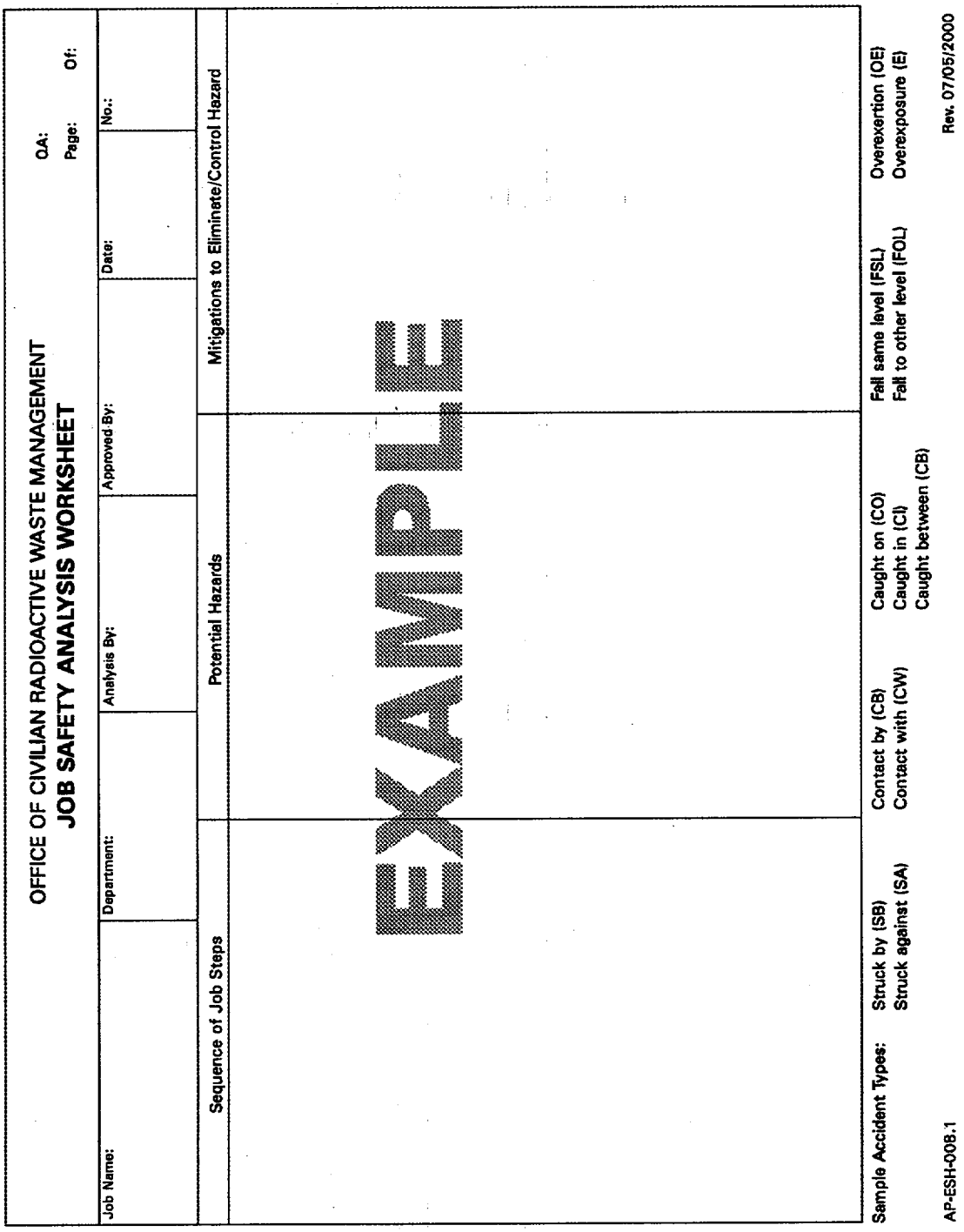
There is no standard or requirement stating the number of job steps that must be identified in an analysis. Some jobs may have only two or three steps; some may need several more. Experience with conducting JSAs has shown that five to eight steps is a reasonable number. If many more steps are needed to describe the job, then it is advisable to break the task down further into two or more large segments and analyze these separately.

Once the job has been broken into steps, the supervisor should enlist the help of employees who will perform this work, or have experience in similar work, and have them review the job step sequence as being correct and that no steps are omitted. Names of all employees participating in the development of the JSA shall be listed in the "Analysis By" field of the JSA form. Job steps are then listed sequentially in the left-hand column of the worksheet.

The second part of the analysis entails review of each step to identify the realistic hazards that may occur. Do not overlook exposure hazards that may be created in the performance of the task. Any task involving chemicals is an obvious candidate for these potentials. Other environmental agents such as dust generation and equipment noise must be kept in mind. When listing the hazards, simultaneously record the type of accident or exposure that may occur. At the bottom of the worksheet, there is a list of typical accident types with codes assigned to provide a shorthand way of writing them in the worksheet spaces. The objective of this phase is to identify all actual or realistically potential hazards associated with the job.

Getting this phase of the analysis fully completed is critical, as well as being the most difficult, because omissions will result in a faulty JSA that may be used as a training guide. Input from experienced employees is very helpful here. **No effort should be made to develop solutions or safeguards simultaneously when performing this step.** The potential accidents or hazards are recorded in the center column of the worksheet opposite each step.

After this phase is complete, the safeguards or safe procedures required to eliminate or reduce the potential for each hazard to an acceptable level are identified. These are written in the worksheet's right-hand column, next to their corresponding hazard. The first consideration must be what engineering changes can be effected to provide a solution. If no solution, or an incomplete solution, is the result of this type of correction, then the second consideration is to employ administrative controls, e.g., limiting the time of personnel exposures, to mitigate the hazard. If that is not viable, or the hazard is still not effectively eliminated or reduced, then the last resort is use of personal protective equipment.



OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
JOB SAFETY ANALYSIS WORKSHEET

QA:
Page: Of:

Job Name:	Department:	Analysis By:	Approved By:	Date:	No.:

Sequence of Job Steps	Potential Hazards	Mitigations to Eliminate/Control Hazard
EXAMPLE		

Sample Accident Types:
Struck by (SB)
Struck against (SA)
Contact by (CB)
Contact with (CW)
Caught on (CO)
Caught in (CI)
Caught between (CB)
Fall same level (FSL)
Fall to other level (FOL)
Overexertion (OE)
Overexposure (E)

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Attachment 7 – Conducting a Job Safety Analysis (Continued)

Conducting a Personal Protective Equipment Hazard Assessment

General Guidelines

The following hazard assessment steps should be taken to assess the need for PPE:

1) Survey by conducting a walk-through of the area or operation in question. The survey is to identify the sources of the hazards to workers. Consideration should be given to the basic hazard categories:

   - Impact
   - Penetration
   - Compression (roll-over)
   - Chemical
   - Heat/Cold
   - Dust/silica
   - Light/lasers
   - Radon.

NOTE: The hazard evaluation survey team should consist of a line management representative, S&H personnel, and workers familiar with the job or process.

2) Sources should be observed during the walk-through survey as:

   - Motions and work practices (e.g., machinery, tool, or personnel movement)
   - High temperature that could result in burns, eye injury, or ignition
   - Types of chemical exposure
   - Harmful dust/silica
   - Light radiation (e.g., welding, cutting, lasers)
   - Falling or dropped objects
   - Sharp objects that may pierce feet or cut hands
   - Rolling or pinching objects that may crush feet
   - Layout of workplace, and location of workforce and electrical hazards. Additionally, accident/incident data should be reviewed to identify problem areas.

3) Frequency of exposure potential needs to be noted.

4) Organize and Analyze Data. Estimate the potential for injury by reviewing and determining the type, level of risk, and seriousness of potential injury from each of the hazards in an area. The possibility simultaneous hazards should be considered.

5) Reassess the work site annually or whenever new equipment or processes are implemented whichever occurs first. The reevaluation process shall include review of past accident, Lessons Learned, and incident records and suitability of PPE selected.

   NOTE: The PPE selected should not create a greater hazard than already exists.

Fitting the Device:

Careful consideration should be given to comfort and fit of the device. Poorly fitting PPE will not afford the necessary protection. Therefore, ensure that the correct size is selected.

Devices with Adjustable Features–Adjustments should be made to ensure that the device is comfortable and will remain in proper position. Follow the manufacturer's recommendation for fitting the devices.

Selection Guidelines for Eye and Face Protection

Eye protection shall be required for all ESF underground and related craft support activities. Eye, face, and skin protection shall be considered for all chemical transfer and use operations.

Notes to Eye and Face Protection Selection:

1) Adequate protection to the highest hazard of an operation should be provided.

2) Face shields and welding helmets should be worn over primary eye protection.

3) Filtered lens shall meet requirement for shade designations in 29 CFR 1910.133 (a) (5), Labor: Eye and Face Protection.

   Tinted and shaded lenses are not filtering lens unless they are marked or identified as such. Select the darkest shade that allows for task performance.

4) Persons with prescriptive (Rx) lenses must wear either protective devices fitted with prescription lenses or protective devices designed to be worn over regular prescription eyewear.

5) Contact lenses may be worn under standard protective eyewear.

6) Clean eyewear is required in dusty or foggy conditions.

Selection Guidelines for Head Protection

All head protection (helmets) is designed to provide protection from impact and penetration hazards caused by falling objects. Head protection is also available that provides protection from electric shock and burn. When selecting head protection, knowledge of potential electrical hazards is important. Class A helmets, in addition to impact and penetration resistance, provide electrical protection from low-voltage conductors (they are proof tested to 2200 volts). Class B

helmets, in addition to impact and penetration resistance provide electrical protection from high-voltage conductors (they are proof tested to 20,000 volts). Class C helmets provide impact and penetration resistance (they are usually made of aluminum that conducts electricity), and shall not be used on the YMP.

Selection Guidelines for Foot Protection

Safety shoes and boots that meet the ANSI Z41-1991 Standard provide both impact and compression protection. All YMP employees, scientist, and others who enter construction/underground areas at the YMP shall use safety shoes that cover the ankles.

Selection Guidelines for Hand Protection

Gloves are often relied upon to prevent cuts, abrasions, burns, and skin contact with chemicals that are capable of causing local or systemic effects following dermal exposure. No individual glove provides protection against all potential hand hazards. Commonly available glove materials provide only limited protection against chemicals. Therefore, it is important to select the most appropriate glove for a particular application and to determine how long it can be worn, and whether it can be reused.

It is also important to know the performance characteristics of gloves relative to the specific hazard anticipated (e.g., chemical hazards, cut hazards, flame hazards). Standard glove test procedures should assess these performance characteristics. Before purchasing gloves, the ES&H staff will need to provide documentation from the manufacturer or consensus standard or authoritative source that the gloves meet the appropriate test standard(s) for the hazard(s) anticipated.

NOTES: Other factors to be considered for glove selection include:

1) As long as the performance characteristics are acceptable, in certain circumstances, it may be more cost effective to regularly change less expensive gloves than to reuse more expensive types.

2) The work activities of the employee should be studied to determine the degree of dexterity required, the duration, frequency, and degree of exposure of the hazard, and the physical stresses that will be applied.

3) The toxic properties of the chemical(s) must be determined; in particular, the ability of the chemical to cause local effects on the skin and/or to pass through the skin and cause systemic effects.

4) For mixtures and formulated products (unless specific test data are available), a glove should be selected on the basis of the chemical component with the shortest breakthrough time, because it is possible for solvents to carry active ingredients through polymeric materials.

5) Employees must be able to remove the gloves in such a manner as to prevent skin contamination.

Respirators

The use of, care, qualifications, and other respiratory requirements are defined in LP-ESH-020-M&O, *Respiratory Protection*. Respirator protection shall be required for all YMP employees, scientists, and others who enter construction/underground areas.

Hearing Protection

The use of, care, qualifications, and other hearing protection requirements are defined in PRO-SH-004, *Hearing Conservation Program*. Hearing protection is required in posted job areas.

Electrical Protection

Electrical PPE appropriate to the type of work conducted is addressed in the M&O Electrical Safety Manual, BAB000000-01717-3500-00001.

Cleaning, Maintenance, and Defective/Damaged PPE

All PPE shall be kept clean and properly maintained. Cleaning is particularly important for eye and face protection where dirty or fogged lenses could impair vision.

PPE should be inspected, cleaned, and maintained at regular intervals so that the PPE provides the requisite protection. Contaminated PPE, which cannot be decontaminated, will be disposed of in a manner that protects employees from exposure to hazards (e.g., Environmental Services or IH will provide directions regarding disposal of contaminated PPE.)

Defective or damaged PPE shall be removed from service immediately by the employee using the PPE. Replacements will be furnished by the manager/supervisor before work is resumed.

Selecting and Documenting PPE Selection

The PPE Hazard Selection form (see Attachment 4) shall be used to document the PPE selection process. Table 1 of Attachment 1 should be used to select the PPE.

Training

Each employee shall be provided training to ensure the employee knows:

- When PPE is necessary
- What type of PPE is necessary
- How to don, doff, adjust, and wear PPE
- Limitations of PPE
- Proper use, care, maintenance, useful life, and disposal of PPE.

Each employee shall be able to demonstrate an understanding of the training and the ability to use the PPE properly before being allowed to work in areas requiring PPE.

Training may be formal, hands-on, at safety meetings and as otherwise practical.

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT QA:
PPE HAZARD ASSESSMENT Page 1 of

Facility:	Assessor:
Area:	Date of Assessment:
Task or Job Function:	I, _____ (name) certify that the evaluation of the identified work areas was conducted on: _____ (date)

SECTION 1. Eye Hazard (check the appropriate box)			SECTION 2. Describe Specific Hazards	SECTION 3. Identify type of PPE required for those hazards delineated in Sec. 2. (See Appendix A for eye and face protection chart)
Eye Hazard	Yes	No		
Impact				
Penetration				
Chemical				
Heat				
Light/Radiation				

SECTION 1. Head Hazard (check the appropriate box)			SECTION 2. Describe Specific Hazards	SECTION 3. Identify type of PPE required for those hazards delineated in Sec. 2. (Consult ANZI Z89.1-1986)
Head Hazard	Yes	No		
Burn				
Electric Shock				
Impact				
Penetration				
Chemical				

SECTION 1. Foot Hazard (check the appropriate box)			SECTION 2. Describe Specific Hazards	SECTION 3. Identify type of PPE required for those hazards delineated in Sec. 2. Consult ANZI Z41.1-1991)
Foot Hazard	Yes	No		
Chemical				
Compression				
Impact				
Puncture				
Penetration				

SECTION 1. Hand Hazard (check the appropriate box)			SECTION 2. Describe Specific Hazards	SECTION 3. Identify type of PPE required for those hazards delineated in Sec. 2.
Hand Hazard	Yes	No		
Burn				
Electric Shock/Arc				
Impact				
Penetration				
Chemical				

SECTION 1. Respirator Hazard (check the appropriate box)			SECTION 2. Describe Specific Hazards	SECTION 3. (check one)	Cartridge Type
Respiratory Hazard	Yes	No		Half face	
Gas				Full face	
Vapor				Quarter face	
Fumes				Powered air	
Dust				Purifying (PAPR) SCBA	
Mist				Air line	
Asphyxia				Escape pack	
Particulates				None needed	

SECTION 1. Other Hazard (check the appropriate box)			SECTION 2. Describe Specific Hazards	SECTION 3. Identify type of PPE required for those hazards delineated in Sec. 2.
Other Hazard	Yes	No		
Burn				
Electric Shock/Arc				
Impact				
Penetration				

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Attachment 8 – Conducting a Personal Protective Equipment Hazard Assessment (Continued)

Conducting an Occupational Exposure Assessment

The OEA program provides a systematic risk-based approach to the anticipation, recognition, evaluation, and control of workplace exposures. This program standardizes the methodologies for OEAs throughout the Site.

Additional benefits for this program include:

- Potential occupational health risks, excluding ionizing radiation and ergonomics, are systematically assessed and ranked.
- Provisions for Site-wide management of OEAs to be used by all Site industrial hygienists in performing OEAs, and evaluating exposure.
- Establishment and documentation of employee exposure for historical record.
- The focusing of resources on activities with the greatest potential occupational health risks.
- Provisions for a cost-effective air monitoring program.
- Written certification of workplace evaluation of hazards, as required by the 29 CFR 1910 Subpart I, Personal Protective Equipment.

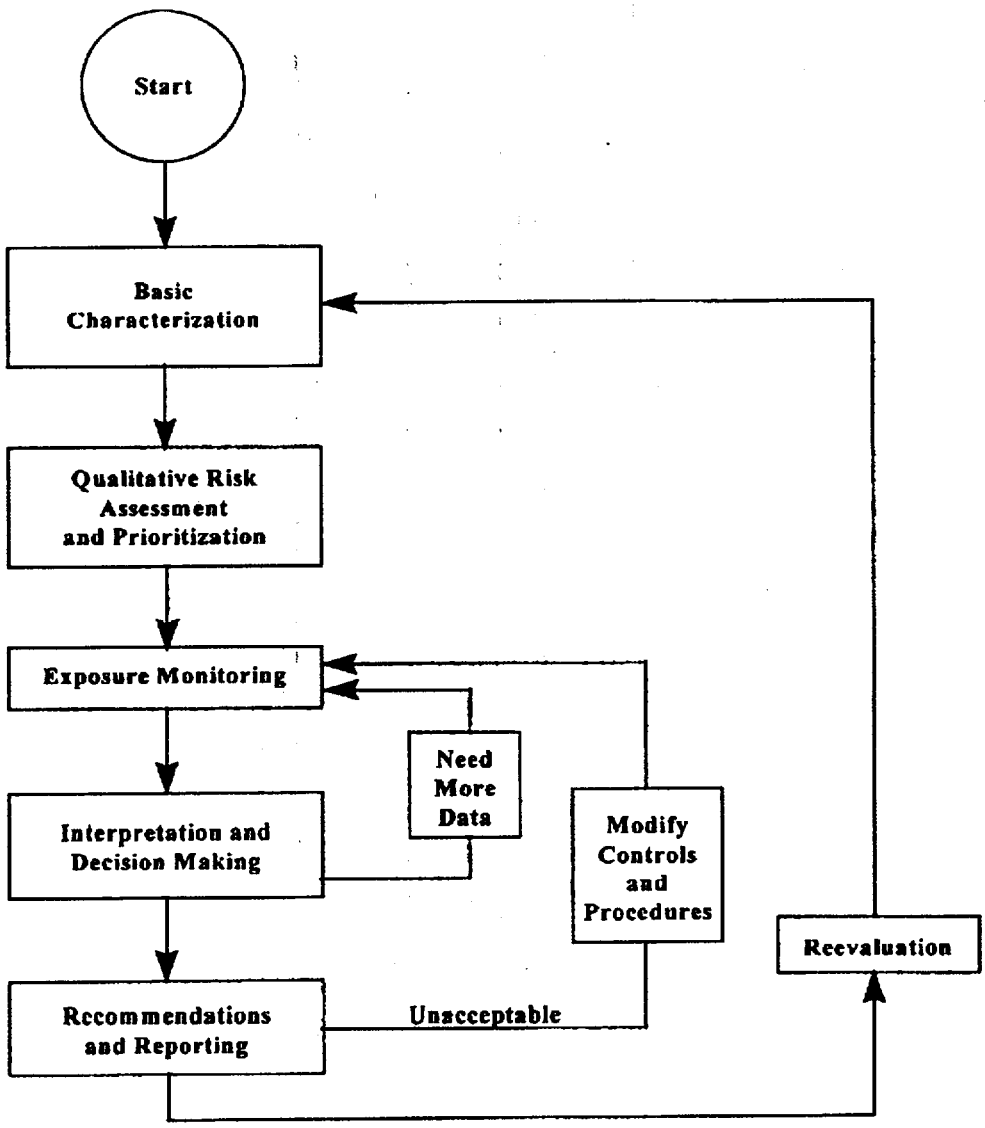
The goals of the OEA process are to:

- Identify high-risk exposure activities and evaluate effectiveness of controls.
- Document historical exposures and communicate exposures to the worker and management.
- Demonstrate compliance with exposure guidelines.
- Assign employees to Similar Exposure Groups (SEGs) and use statistical sampling methodologies to determine the exposure profile (see Attachment 3).

The OEA process will be comprised of the following five components, as identified in Figure 1, Occupational Exposure Assessment:

- Basic Characterization
- Qualitative Risk Assessment
- Exposure Monitoring Strategy
- Interpretation and Decision Making
- Recommendations and Reporting.

Figure 1. Occupational Exposure Assessment



BASIC CHARACTERIZATION

The first step in the OEA process is to perform a basic characterization. The primary purpose of the basic characterization is to establish an SEG. Basic characterization involves four major components (see Figure 2, Basic Characterization):

- Workplace characterization
- Work force characterization
- Occupational stressor characterization
- Determination of SEGs.

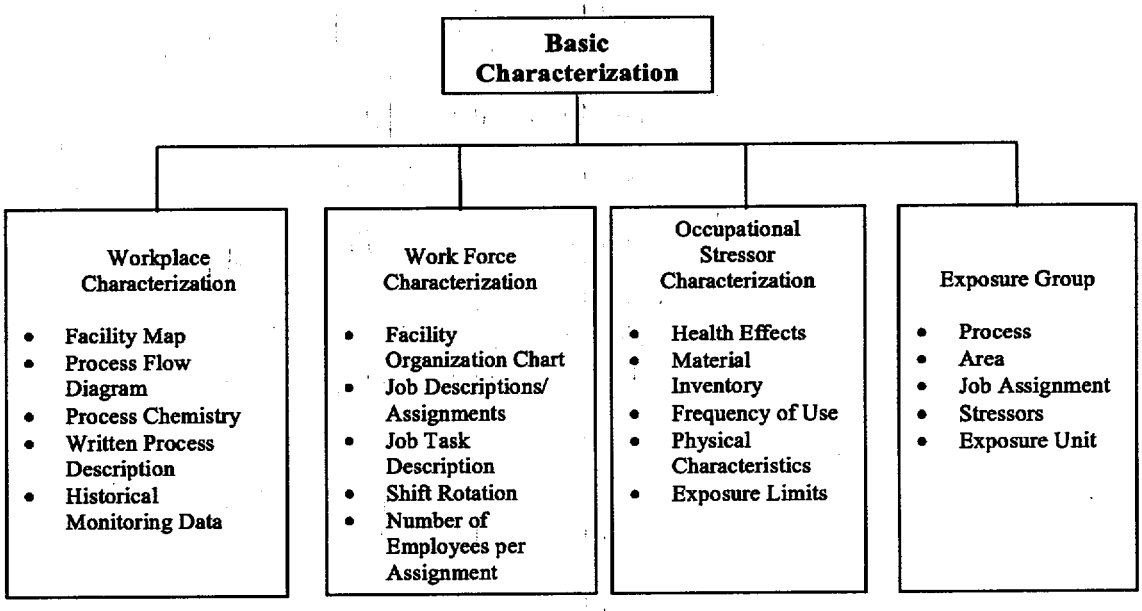
This attachment provides the necessary information to perform an adequate basic characterization to identify:

- Chemical, biological, and physical stressors in the work environment

NOTE: The health hazard inventory may be used as a basic document to initiate this process.

- Health effects associated with excessive exposure for the agents identified
- OELs for each agent
- Interaction between workers and the work environment for each identified stressor
- Key operations and activities that pose the greatest potential for exposure to these agents.

Figure 2. Basic Characterization



Exposures can be via the air, skin or ingestion routes. Ratings should not take into consideration the use of PPE. The magnitude of exposure potential may be inferred through the relationship of exposure to the OEL. Consistency of application of this rating scheme is essential in determining a useful exposure rating (ER).

Selection of major and minor exposure potential will reduce the number of chemical and physical agents for exposure monitoring (see Figure 3, Selection of Major and Minor Exposure Potential). Identification of major and minor exposure groups is necessary because relatively few chemical and physical agents contribute to significant exposures that require exposure monitoring.

The major/minor narrowing of chemical and physical agents is a qualitative, multiple-step process to be applied to all SEGs. Each step classifies exposures as minor (minimal risk) or major (more than minimal risk).

QUALITATIVE RISK ASSESSMENT

Qualitative risk assessment is the second step in the OEA process. The purpose of the qualitative risk assessment is to qualitatively rate the degree of exposure posed by each operation and/or work activity for each SEG. This section describes methods for estimating an ER and a health effect rating (HR) for each agent and to establish a SEG priority ranking based on qualitative risks faced by the workers in each SEG.

Qualitative risk assessments involve professional judgment. Decisions regarding potential risks are subjective. The use of trained, qualified and experienced employees is essential in performing qualitative risk assessments.

The following subsections will discuss the methodology of performing qualitative risk assessments:

Exposure Ratings

The industrial hygienist should use past exposure data, exposure modeling, and/or professional judgment to assign ERs. The use of past exposure data will have to be carefully considered in decommissioning and decontamination operations where, for the most part, the existence of steady-state concentrations does not normally exist and exposures usually are not predictable over time. Qualitative ERs are based on a scale of 0 (no exposure) to 4 (very high exposure). Table 1, Qualitative Exposure Rating, shows a generic qualitative ER scheme with five categories of exposure. The overall score identified in the description column of Table 1 takes into account the level of control, frequency of use, and dispersion of the agent in question. This table should be used in performing qualitative ERs. The ER is a numerical representation of the degree of exposure risk to a stressor. Qualitative exposure estimation is used to develop an ER for each SEG.

Figure 3. Selection of Major and Minor Exposure Potential

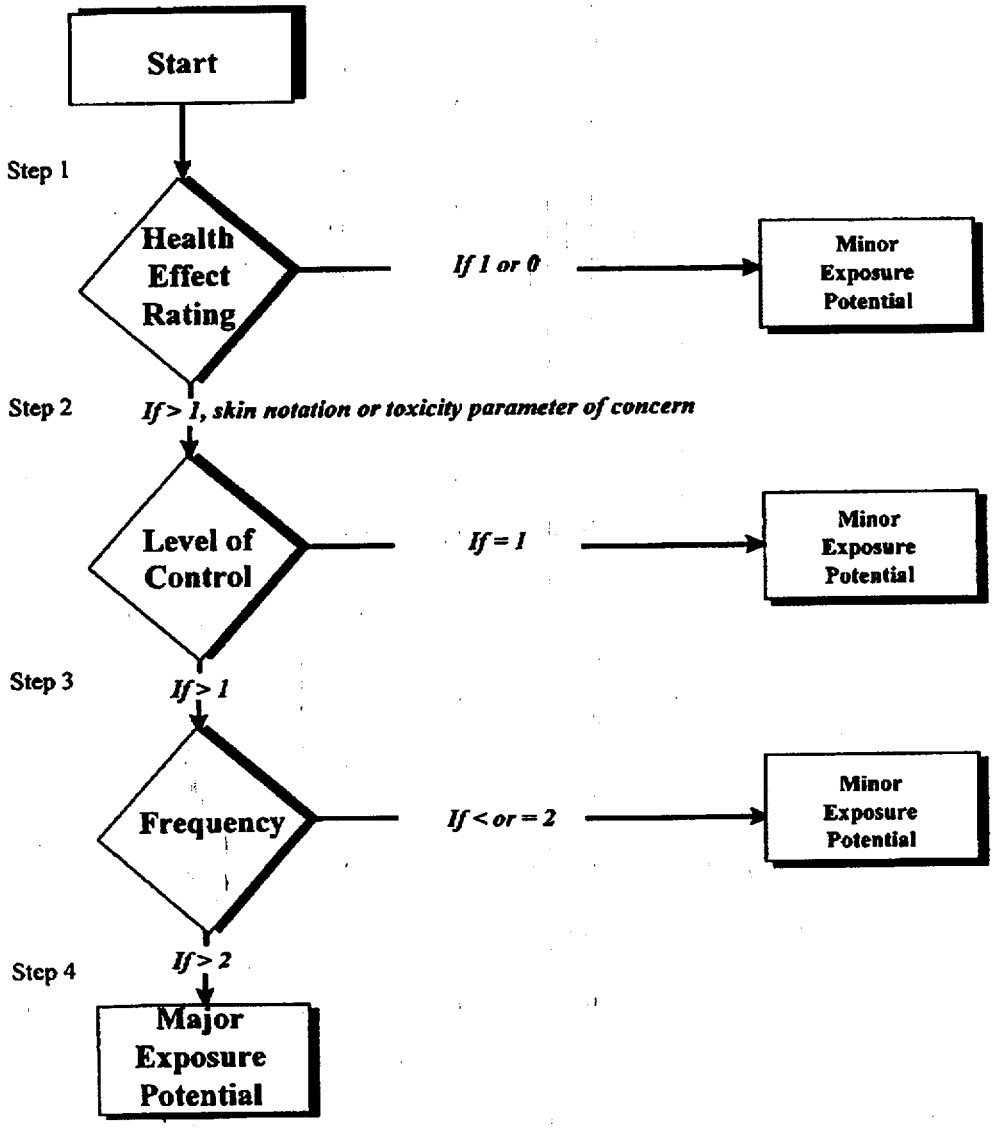


Table 1. Qualitative Exposure Rating

Category	Description
0 - No Exposure	No contact with chemical, physical, or biological agent (agent). (Overall ER Score: <6)
1 - Low Exposure	Infrequent contact with agent at low exposure. (Overall ER Score: 6-12)
2 - Moderate Exposure	Frequent contact with agent at low concentrations or infrequent contact with agent at high concentrations. (Overall ER Score: 12-18)
3 - High Exposure	Frequent contact with agent at high concentrations. (Overall ER Score: 18-24)
4 - Very High Exposure	Frequent contact with agent at very high concentrations. (Overall ER Score: >24)

a) Step 1

All stressors with a qualitative HR of 1 or less would be classified as minor. Other toxicological effects such as carcinogenicity may require further consideration. Refer to subsection 1.2.2 for specific guidance on HRs.

b) Step 2

The extent an exposure is prevented or reduced through the use of engineering controls, work practices, or PPE is evaluated with a level of control rating. In assessing the level of control, PPE is not assumed to be an adequate substitute for engineering controls. The matrix provided as Table 2, Level of Control Rating Matrix, shall be used to assign a level of control rating.

Table 2. Level of Control Rating Matrix

Rating	Level of Control (L)
1	Effective engineering controls (meet designation) in place to contain/remove airborne contaminants from the work area.
2	Ineffective engineering controls (conditional) or fails designation in place: using PPE and administrative controls as primary method of minimizing worker exposures.
3	No controls in place, visible airborne contaminants, odors or other sensory response indicated potential for exposure exists.

c) Step 3

The frequency of use of a chemical and physical agent is important in determining the potential exposure hazards associated with using the agents in question. Table 3, Frequency of Use Rating Matrix, is used to provide a rating based on the frequency of use within a SEG. Professional judgment needs to be used in cases of undefined exposures.

A minor classification is assigned to the stressor if the frequency of use is 2 or less and the level of control rating is equal to 1. All frequency of use ratings of 3 or greater warrant further review of the process and or activity.

Table 3. Frequency of Use Rating Matrix

Rating	Frequency Description (F)
1	Stressor is present in the workplace less than once per month.
2	Stressor is present at least one day per month.
3	Stressor is present at least one day per week or stressors have Short-Term Exposure Limits (STEL) or ceiling value.
4	Stressor is present in the workplace for up to four hours per day.
5	Stressor is present in the workplace grater than four hours per day.

d) Step 4

The fourth step is to determine an overall ER for each chemical and physical agent for each SEG. The overall ER is a function of level of control, frequency and dispersion. The dispersion rating assesses a materials ability to become airborne and ultimately inhaled. Table 4, Dispersion Rating Matrix, provides a rating scheme for dispersion.

Table 4. Dispersion Rating Matrix (D)

Rating	Vapor Pressure (@ 20°C)	Particle Size
1	Low (<50 mm Hg)	Nonrespirable (>25 um)_
2	Moderate (50-250 mm Hg)	Moderate (10-25 um)
3	High (>250mm Hg)	Respirable(< 10 um)

An overall ER is then determined by use of the following equation and comparison of the result to Table 5, Qualitative Exposure Estimation Exposure Rating.

$$L \times F \times D = \text{Overall ER} \qquad \text{(Eq. 1)}$$

where

L = Level of Control
F = Frequency of Use
D = Dispersion.

Table 5. Qualitative Exposure Estimation Exposure Rating

Overall ER	Exposure Rating
<6	0
6-12	1
12-18	2
18-24	3
>24	4

1.2.2 HRs

The HR is a numerical value ranging from zero (low) to four (very high) and is used to define the toxicity or potency of target organ response to hazardous material exposure. The HR shall be assigned by using the NFPA health ratings from Material Safety Data Sheets. Because there are limitations with HRs assigned by the NFPA, careful consideration shall be demonstrated for compounds with severe chronic health effects, such as carcinogenicity or compounds that contribute to exposure through skin absorption. Table 6, Qualitative Health Effect Rating, shows a generic scheme with five categories of exposure. This table should be used in performing qualitative HRs. The person performing this OEA must use a great deal of professional judgment in applying ratings schemes such as these. There is a great deal of uncertainty in the available health effects data. Where uncertainty exists, one should error on the side of health and safety.

Table 6. Qualitative Health Effect Rating

Category	Health Effects
0	Reversible effects of little concern or no known suspected adverse health effects.
1	Reversible health effects of concern.
2	Severe, reversible health effects of concern.
3	Irreversible health effects of concern.
4	Life threatening or disabling injury or illness.

1.2.3 Qualitative Risk Ranking and Prioritization

The purpose of the two ranking schemes identified above is to establish the qualitative relative risk of SEGs and to prioritize SEGs based on this risk ranking. Relative risk will range from little or no risk to the highest risk of health effects. Figure 4, Qualitative Risk Ranking, identifies a form of ranking. An activity that is identified with a HR of 4 and an ER of 4 would have a very high qualitative risk ranking (considered to be a high-risk activity). It is intuitively obvious that a SEG with a HR of 4 and an ER of 4 would get top priority for additional review of operations, controls, and implementation of an air-monitoring program. The need for professional judgment to determine further actions comes into play in the middle ranges.

This risk ranking approach reduces the number of SEGs needing further evaluation to those that contribute significant risk of exposure to employees. Higher rankings should be given to exposures controlled by PPE than to exposures controlled by process and plant design. Higher rankings should be given to the substances most likely to be at or above OELs.

The outcome of qualitative risk assessment is to prioritize the SEGs based on relative risk. Those groups with negligible or low risk will likely not be monitored. SEGs with moderate risk will be monitored to some degree, and high and very high risk ratings will receive the most monitoring.

1.3 EXPOSURE MONITORING STRATEGY

A quantitative assessment of exposure will entail some form of exposure monitoring or sampling strategy of the worker to quantify the exposure and compare exposure results to the OEL and to evaluate controls. Careful thought prior to monitoring pays large dividends in cost effectiveness. Therefore, it is essential that Site industrial hygienists utilize the following protocol in identifying monitoring needs and protocols. Monitoring will be performed in accordance with the following protocol:

1.3.1 Identify a Model for Exposure Pathways

The complexity of exposure scenarios requires consideration of all possible exposure pathways before monitoring techniques are selected. The industrial hygienist must select whether the exposure is primarily from inhalation, skin absorption, ingestion or a combination of the three. Once the critical exposure pathway has been determined, tailored monitoring strategies can be determined to evaluate critical pathway exposures.

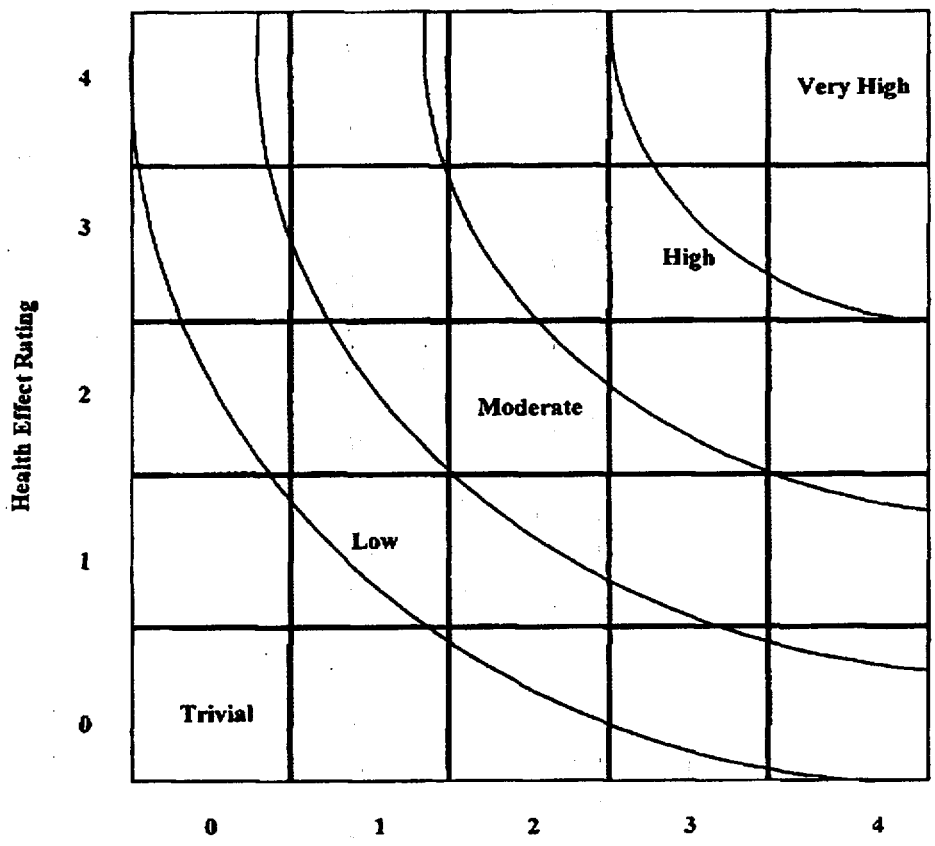


Figure 4. Qualitative Risk Ranking

1.3.2 Identify Monitoring Objectives

The monitoring objectives can include baseline, diagnostic, and compliance monitoring. Baseline monitoring is performed to quantify the range of exposures and distribution of exposures. Diagnostic monitoring is performed for a specific case and the primary reason to perform diagnostic monitoring is to identify the main source and activities causing exposures. Compliance monitoring is necessary for comparisons with OELs. Once the monitoring objectives are determined, then the monitoring methods needs to be identified.

1.3.3 Monitoring Methods

Both personal and area monitoring methods are used to quantify exposures. However, only personal monitoring is used to provide comparisons with the OELs because worker tasks often influence breathing zone concentrations. For personal monitoring, a proper mix of full-shift and short-term sampling may be the best approach for evaluating personnel exposures. Biological monitoring may also be appropriate in some instances and should be discussed with medical staff before one commences with biological monitoring. Area monitoring may be used to assess the level of specific contaminants in the air and to evaluate background concentrations. However, area monitoring can only be used as a substitute for personnel monitoring under specific coordination with the IH Lead.

1.3.4 Number of Samples Required

Once the SEG is identified, and the qualitative risk assessment has determined that sampling is necessary, then sampling should be performed utilizing random methods. A worker from the SEG should be selected at random and then sampled.

1.3.5 Random Samples

To utilize statistical strategies, random samples must be taken. Random sampling will allow for making estimates of population parameters of an exposure distribution. Statistical theory reveals that there is a point of diminishing return in performing additional sampling of normal distributions. According to the AIHA's publication, *A Strategy for Occupational Exposure Assessment*, a plateau is reached around 6 to 14 random samples per static operation. At least six random samples should be taken for each SEG monitored, unless exposures are much less than or greater than the standard. It is imperative that sampling be conducted utilizing random methods to allow for statistical testing and interpretation.

NOTE: If non-random samples are taken, then professional judgment will be used to interpret results, not statistical tests. The sampling strategy identified in the Statistical Analysis section of this Attachment shall be utilized to perform statistical analysis.

1.4 INTERPRETATION AND DECISION MAKING

Once sampling has been completed, one needs to make a determination of the exposure data: exposures are acceptable, exposures exceed the OEL, or additional sampling may be necessary due to a number of reasons.

These decisions are based on statistical tests and professional decision. Before one can use statistical tools, one must determine if the data meet population distribution assumptions. If the distribution seems adequate, one can proceed to use parametric statistical analysis. Parametric statistical analysis is based on the assumption that the true shape of the population distribution is known. The power of non-parametric statistics usually require more samples for statistical-based decision making.

This procedure is not intended to provide instruction on statistical theory. Industrial hygienists who use this procedure will need to understand statistical theory and its applicability to their specific activity. The information provided as Attachment 3 is intended to provide a guide of the types of statistics to be applied for industrial hygienist monitoring activities in determining exposures to SEGs. The use of descriptive statistics, confidence intervals, and tolerance intervals are all powerful tools to assess exposure in data sets that are taken randomly and are normally distributed. Industrial hygienists shall use these statistical tools to assess exposures.

The outcome of this exposure assessment strategy is to determine if exposures are acceptable or not. If unacceptable, a review of controls is necessary in order to reduce the exposure. Once new controls are established, a new sampling data set will be needed and analysis of acceptability will again need to be performed. All information leading to the decision shall be documented and recommendation for future sampling needs shall be made.

1.5 RECOMMENDATIONS AND REPORTING

Each exposure assessment shall be documented with a written report. This report will be the primary vehicle for communicating survey results to workers and management. These reports will be used in subsequent work planning and in evaluating IH resources to support various work activities.

The report shall include the following information:

- Summary of Activities–This will include purpose, findings, and recommendations.
- Exposure Evaluation Criteria–To include health effects and exposure potential, job description, and specific activities to be performed. Information describing the PPEHA (see Attachment 8) process should be used to define the effectiveness of any PPE utilized.

- Monitoring and Analytical Methods - Include agents sampled for, NIOSH methods, potential biases and sources of error (to also include quality assurance techniques). Include tasks monitored, workers monitored or workers represented by monitoring sampling methods, control measures in place, use of PPE and any other factors.
- Results-Discussion of results and recommendations.
- Period of Reevaluation
- References-Including any tables, calculations, etc.
- Decision Logic-Logic used to determine SEGs.

1.6 REEVALUATION

As stated in Section 1.5 of this Attachment, the report shall include a recommended period for reevaluation. Some workplaces may require less frequent reevaluations than other areas. Industrial hygienists need to be informed in changes to operations that may impact the potential exposures to the SEG. It is important that reevaluations be performed in the same manner as the initial assessment in order to properly compare the results of the two assessments. Triggers for reevaluation may include process changes, illnesses, new toxicological data, employee complaints and changes to regulatory drivers.

SAMPLING STRATEGY

A sampling strategy is developed based on the ER. All major SEGs and all compounds with regulatory requirements for monitoring are included in the sampling strategy. The sampling strategy is composed of the following components:

- Number of samples specific to a job site/location during a static operation
- Selection of employees to sample (worst case or random)
- Sample type (personal breathing zone or area)
- Sample duration (full period single or consecutive, partial period single or consecutive, ceiling, short-term exposure limits [STEL], or grab).

The number of samples to be collected is based on Table 7, Number of Samples per Risk Rating. Three samples are collected to calculate an arithmetic or geometric mean exposure level per year per stressor with an ER of 1 or 2. Six samples are collected for stressors with an ER of 3 or 4 to minimize distribution uncertainty about the mean and variance.

Table 7. Number of Samples per Risk Rating

Exposure Rating	Sample per Year
0	Three samples for 10% of all Minor Stressors
1	3
2	3
3	6
4	6

When practical, random sampling versus worst case is the method of choice. Stressors with OSHA chemical specific health standards require initial baseline monitoring. These exposures are evaluated by monitoring worst case.

The intent of the OEA program is to collect personal breathing zone samples. **Workplace conditions may dictate other sampling strategies.** Professional judgment is used in determining the appropriate sampling method.

Continuous exposure to the stressor throughout the work shift requires full period single or consecutive samples. Professional judgment is used to determine the sampling period if the exposure is less than eight hours.

STATISTICAL ANALYSIS

Ceiling or STEL samples shall be collected for all stressors having a ceiling or STEL OEL. The variability of short-term sampling events makes worst-case exposure monitoring the most desirable method to detect the maximum expected concentrations of the stressor. If the stressor of concern has a ceiling or STEL OEL, a minimum of three samples are collected during the shift and those samples constitute one sampling event, as addressed in Table 1 of this attachment.

MONITORING

Monitoring and analytical methods are identified in the Industrial Hygiene Procedures Manual. This manual is to undergo revision and current OSHA and NIOSH methods are to be used. When NIOSH or OSHA sampling and analytical methods are not available, a chemist at an AIHA accredited laboratory shall be consulted for the best sampling protocol.

This attachment provides insight into the significance of the exposure measurements collected, the decisions that can be made, and conclusions that can be drawn. The two major questions addressed are "What is the exposure level of an employee working in a SEG?" and "Is the level acceptable or in compliance?"

For the OEA program's purpose, the exposure measurement used for statistical analysis is a function of the way a material can affect the body. Items for consideration are the time of onset of the symptoms from exposure, the severity of the effect, and the elimination rate of the material from the body. For materials that have an elimination rate on the order of minutes to hours, an eight hour Time Weighted Average is used. If the primary characteristic of a material is to produce acute effects, ceiling or STELs are used.

STATISTICAL TOOLS

In using the statistical tools that follow, three assumptions are made:

- The available population of exposure situations is large
- The Centering Value of the exposure measurements is equal to the true Centering Value of the population
- The variability term (standard deviation or geometric standard deviation) is equal to the true variability of the population.

It should be noted that a degree of caution should be used when interpreting the significance of Centering Value and Variability with small data sets (typically less than eight). Caution means that it should be stated that the conclusions are based upon limited data. In those cases where significant decisions must be made regarding an employees health or the expenditure of large sums of money, it may be concluded that additional data are required. However, if a decision must be made with limited data, these statistical tools aid in making an informed decision.

Centering Value

The appropriate centering value is the arithmetic mean for a normal distribution and a geometric mean for a lognormal distribution. Evaluation of the data will determine the type of distribution and the appropriate value to apply.

Tolerance Level Value

The Tolerance Level Value is the measure of variability in the distribution of exposure opportunities and reflects the percent of the expected exposure values that are below a set level. For example, the 90 percent Tolerance Level Value is the exposure value at which 90 percent of the exposure opportunities are below. It should not be concluded that overexposing employees 90 percent of the time is acceptable. The Tolerance Level Technique only provides a measure of the degree of control over exposures. Tolerance Level Values are a function of the standard deviation or geometric standard deviation of the data set calculated using the following formulas.

Normal Distribution

$$Tol_{90} = \bar{x} + [SD \times (1.28)] \qquad \text{(Eq. 1)}$$

where

Tol_{90} = 90% Tolerance Level

$\bar{x}$ = Arithmetic mean

SD = Standard deviation

1.28 = Number of standard deviation units corresponding with the 90th percentile of the distribution.

Lognormal Distribution

$$Tol_{90} = \text{GM} \times \text{GSD}^{1.28} \qquad \text{(Eq. 2)}$$

where

Tol_{90} = 90% Tolerance Level

GM = Geometric mean

GSD = Geometric standard deviation

1.28 = Number of standard deviation units corresponding with the 90th percentile of the distribution.

After making the assumption that the arithmetic or geometric mean and standard deviation of the exposure measurements are equal to the true arithmetic or geometric mean and standard deviation of the population of expected exposure values, the following conclusion can be drawn; the calculated arithmetic or geometric 90 percent Tolerance Level Value is that exposure level at which 90 percent (i.e., 900 out of 1000) exposure values are likely to be at or below.

Percent Compliance Level

The Percent Compliance Level is a compliment of the Tolerance Level Value. With the Tolerance Level Value, the percentile is specified and a level is determined. With the Percent Compliance Level, the OEL is established (e.g., OSHA Permissible Exposure Limits [PELs], American Conference of Governmental Industrial Hygienists Threshold Limit Values [TLVs]) and the calculation is used to determine the percentage of time the compliance level is met. The following equations are used to calculate the number of standard deviation units to the right of the arithmetic/geometric mean needed for determining percent compliance:

Normal Distribution

$$SDU = \frac{AL - \bar{x}}{SD} \qquad \text{(Eq. 3)}$$

where

SDU = Standard deviation units to the right of the arithmetic mean
AL = Occupational Exposure Limit (PEL, TLV, etc.)
SD = Arithmetic standard deviation
$\bar{x}$ = Arithmetic mean.

Lognormal Distribution

$$SDU = \frac{\log(AL) - \log(GM)}{\log(GSD)} \qquad \text{(Eq. 4)}$$

where

SDU = Standard deviation units to the right of the geometric mean
AL = Occupational Exposure Limit (PEL, TLV, etc.)
GM = Geometric mean
GSD = Geometric standard deviation.

Percent compliance can now be estimated using Table 8, Percent Compliance Level.

Table 8. Percent Compliance Level

Standard Deviation Units	Percent Compliance
2.326	99
1.645	95
1.282	90
1.036	85
0.842	80
0.675	75
0.524	70
0.385	65
0.253	60
0.126	55
0.000	50

The Percent Compliance level is useful in estimating how well a facility is complying or the impact of lowering an accepted level.

Confidence Level

The Confidence Level is a measure of distribution of exposure values around the Centering Value. The Confidence Level is a function of the distributions Standard Error (SE). The SE is calculated by the following equation:

Normal Distribution

$$SE = \frac{SD}{\sqrt{n}} \qquad \text{(Eq. 5)}$$

where

SD = Arithmetic standard deviation of the distribution of exposure values
N = Number of samples in the data set.

Lognormal Distribution

$$SE = \frac{\log(GSD)}{\sqrt{n}} \qquad \text{(Eq. 6)}$$

where

GSD = Geometric standard deviation of the distribution of exposure values
AL = Number of samples in the data set.

A 95 percent two-tailed Confidence Level is determined using the calculated SEs as follows:

Normal Distribution

$$LCL = \textit{arithmetic mean} - 1.96\ (\textit{arithmetic}\ \text{SE}) \quad \text{(Eq. 7)}$$

$$UCL = \textit{arithmetic mean} + 1.96\ (\textit{arithmetic}\ \text{SE}) \quad \text{(Eq. 8)}$$

Lognormal Distribution

$$LCL = (GM) \times (\textit{geometric SE})^{-1.96} \quad \text{(Eq. 9)}$$

$$UCL = (GM) \times (\textit{geometric SE})^{1.96} \quad \text{(Eq. 10)}$$

where

LCL = Lower Confidence Level
UCL = Upper Confidence Level

SUMMARY

This discussion has focused on answering the following two questions:

- Q: What is the exposure level of an employee in an exposure group?

  A: The Centering Value provides an estimate of the most likely exposure level. The Tolerance Level Value and Confidence Level provide an estimate of how extreme the exposures can be.

- Q: Is the level acceptable or in compliance?

  A: The Percent Compliance Level provides a tool to answer this question with limited amounts of data.

With a clear understanding and appropriate use of these statistical approaches, it is possible to characterize exposure and make informed decisions.

Conducting a Medical Needs Analysis

This Attachment establishes when and how an analysis is conducted to determine if field work may progress without close proximity medical care. Established criteria are used in a matrix to provide consistent decision making over a wide range of conditions.

Risk Level–Determine the risk level using the methodology described in Attachment 3. Risks are characterized as either "Very high," "High," "Moderate," "Low," or "Very low." Only one overall risk is established. If several jobs are being conducted within a relatively common area, the evaluation will be based on the task with the highest risk.

Response Time–Estimate the ambulance/EMTs response time based on conservative speeds attainable on the unpaved roads that would be traveled and at the posted speed limits on the paved roads to be traveled. As an additional conservative measure, always add three minutes to the "driving" time to allow time for the EMTs to "scramble."

Population–The total employee population will be used even when several separate jobs are being performed in a relatively common area.

Computation–Using a copy of the worksheet (provided in this Attachment), place the risk level, response time, and population count in the Procedure Matrix box to determine the corresponding "criteria number."

Procedure Matrix

CRITERIA NUMBER	5	4	3	2	1
RISK LEVEL	Very low	Low	Moderate	High	Very high
RESPONSE TIME (in minutes)	< 10	10 - 16	17 - 23	24 - 30	31 or >
POPULATION	< 10	10 - 20	21 - 30	31 - 40	41 or >

The resulting criteria numbers are then added together to obtain the MAL. The MAL is acceptable if the total is 10 or greater. A result of 10 or greater means the job being planned can be conducted without changing any criterion as it relates to medical needs.

If the MAL is less than 10, the M&O manager/supervisor must take additional steps until recalculation produces an acceptable MAL of 10 or greater. The simplest solution usually will be to move the EMTs closer to reduce the response time. However, there may be other ways to mitigate the job risk or reduce the population of employees to change an unacceptable MAL.

Until analysis of the job results in an acceptable MAL of 10 or higher, M&O managers/supervisors will not allow work being planned to proceed.

RISK EVALUATION

The evaluation of risk can be conservatively estimated to provide a realistic value judgment of an event's timing and impact. Several variations of a methodology have been developed and are routinely used in government and industry practice. These variations base their premise on the likelihood of an occurrence (frequency) and the consequences of the occurrence (severity). This method is described in YMP/94-13 and its implementing YAP-30.48. The risk assessment presented here is adapted from the system safety analysis scheme, which is itself adapted from MIL-STD-882C. (Other risk assessment schemes were also studied for input to this procedure.)

EVALUATION CONSIDERATIONS

For the purpose of this procedure, some modification to the system safety analysis method is necessary because it is concerned with evaluating all types of adverse consequences. This analysis is performed to determine a single need; i.e., the necessary proximity of EMTs on jobs of a short duration–one day to a few weeks. Identified risks, attendant with a particular job, have to be measured in occurrence frequencies that experience shows to be probable, even when these expected frequencies have a time span well beyond the actual time needed to perform the job being analyzed. Frequency categories can be varied to some extent. In this determination, five levels are defined. However, severity is almost always described in four levels and these divisions have been retained in this assessment method.

FREQUENCY RATING SCALE

Frequency		Description
A.	Often	Could happen repeatedly, more than once a day or week
B.	Probable	Once a day to once a week
C.	Occasional	From once a week to once a month
D.	Rarely	From once a month to once a year
E.	Unlikely	Has been known to occur, but is improbable

These frequencies are estimated times in which events could occur after all protective mitigations have been put in place. The frequency of an event's probability is to be used conservatively. Emphasis must be placed on whether the event could occur, not whether it will occur, i.e., the risk exists if the event can come about (with mitigations in place), not that the event must actually happen.

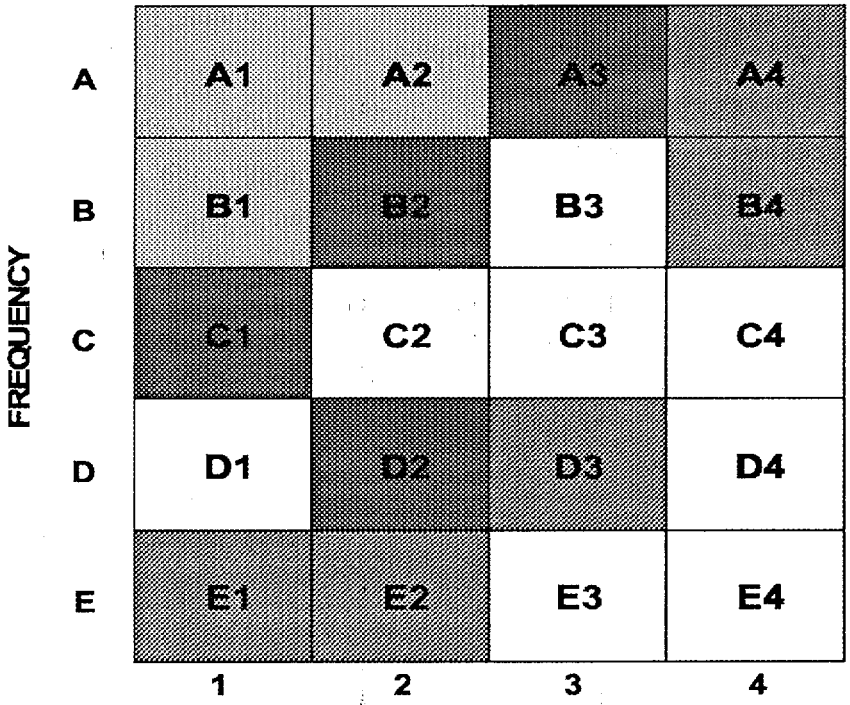
CONSEQUENCE OF AN EVENT

Consequence Level		Maximum Severity
1.	Catastrophic	Death
2.	Critical	Severe injury or illness; permanent, total, or partial disability
3.	Disabling	Results in lost workdays or restricted workdays, full recovery
4.	Negligible	First aid or less in severity

The above Consequence rating levels are self-explanatory and are to be used conservatively. If the event contemplated occurred, what is the realistic severity one would expect given the conditions at hand (mitigations included)?

RISK LEVEL EVALUATION

The risk evaluation will be conducted on the specific job task that presents the greatest hazard and the likelihood of an occurrence. In other words, this evaluation must be driven by the principal purpose of the analysis, which is determining the necessity of bringing EMTs closer to work to respond to the worst-case scenario. When a frequency of A through E and a consequence of 1 through 4 has been selected, the two are combined in the following Risk Assessment Matrix. The resulting position in the matrix is translated, using the list at the bottom of the matrix, directly into a word value. This value is the "risk level" that is plugged directly into the Procedure Matrix.



RISK LEVEL:

VERY HIGH RISK = A1, B1, A2
HIGH RISK = C1, B2, A3
MODERATE RISK = D1, C2, D2, B3, C3
LOW RISK = E1, E2, D3, A4, B4
VERY LOW RISK = E3, C4, D4, E4

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OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT QA:
MEDICAL NEEDS ANALYSIS WORKSHEET Page:_____ of:_____

Analysis Performed by:	Date:
General Location:	Date of Work:

Description of Job(s) to be Performed:

In the matrix below, circle the value determined for each of the three criteria.

PROCEDURE MATRIX

Criteria Number	5	4	3	2	1
RISK LEVEL	Very low	Low	Moderate	High	Very high
RESPONSE TIME (in minutes)	< 10	10 - 16	17 - 23	24 - 30	31 or >
POPULATION	< 10	10 - 20	21 - 30	31 - 40	41 or >

Total of the three criteria numbers:

Actions taken if the MAL is lower than 10: