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United States Government **Department of Energy**

memorandum

DATE: January 12, 2001

REPLY TO
ATTN OF: EM-53 (Levine:301-949-2747)

SUBJECT: Occupational Safety and Health in the Environmental Management Science and Technology Program

TO: Distribution

The new Environmental Management (EM) policy document "Occupational Safety and Health in EM's Science and Technology Program" is attached for your implementation. This document sets forth guiding principles and describes steps that are to be taken to achieve these principles. Through pursuit of these goals, we intend to continually improve safety and health protection for those who develop and use the innovative technologies developed through EM's Office of Science and Technology (OST) efforts.

On April 14, 2000, the Environmental Management Advisory Board (EMAB) transmitted a "Resolution on the Consideration of Occupational Safety and Health in the EM-OST Technology Developmental Program." The EMAB found that "the OST Program addresses occupational safety and health more comprehensively than other federal agencies with development programs in the remediation technology sector." The EMAB also recommended eight actions to further improve OST's performance in this area. I directed the OST and the Office of Safety, Health and Security (OSHS) to work closely in addressing the recommendations in that Resolution. The EMAB recommendations are found in Appendix A to the Policy Document.

On August 22, 2000, a worker was seriously injured in an accident at the Portsmouth Gaseous Diffusion Plant in Piketon, Ohio, while participating in an OST innovative remediation technology demonstration. The Manager, DOE Oak Ridge Operations (DOE ORO), chartered a Type B Accident Investigation Board to investigate the accident. While the investigation report produced no judgments of need relative to OST or other headquarters EM offices, the accident and the investigation report provide strong evidence of the need to improve the way occupational safety and health is addressed in EM's technology development processes. These considerations have been addressed in the Policy Document and will undergo further review over the next several months. The conclusions of the Type B Accident Investigation Board are found in Appendix B to the Policy Document.

In addition, OST and OSHS have developed an Action Plan that addresses the EMAB recommendations, as well as issues raised in the Type B Accident Investigation Board report. This Action Plan culminates in an update of the Safety and Health Policy Document at the end of FY01 and is also attached for your information.

We view this as a dynamic policy and intend to examine our progress and make necessary revisions on an annual basis. Your input to OST (Mac Lankford, 301-903-7924) and OSHS (Bob Goldsmith, 301-903-0221) on issues and successes during this first year would be appreciated.

Carolyn L. Huntoon

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Assistant Secretary for
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Office of Environmental Management
Policy for Occupational Safety and Health in EM's Science and Technology Program
January 2001

A. Introduction and Purpose

The Department of Energy's (DOE's) Office of Environmental Management (EM) is committed to maintaining a program that is second to none in the dedication and skill with which it promotes occupational safety and health for those developing and using new environmental remediation technologies during all phases of development and deployment.

Since 1995, the EM Office of Science and Technology (OST) has conducted a program with the International Union of Operating Engineers (IUOE) to include occupational safety and health (OSH) considerations in the EM technology development program. With this experience we are implementing an improved OSH program built around Integrated Safety Management (ISM) principles. This paper puts forth EM's policy on the integration of OSH into the technology development program and supplements all applicable DOE OSH requirements.

ISM is the full inclusion and integration of environment, safety and health into the totality of work, such that it is an integral part of the whole. This applies to all functions of EM, and specifically to OST's technology research and development efforts. With ISM comes a focus on accomplishing work safely, rather than mere compliance with ES&H requirements and programs for their own sake. The Department's approach is that ISM begins with the fundamental ways in which we operate. For OST, this specifically means our agreements and relationships with end-users, technology developers and others. These agreements, the processes by which they are administered, and the projects and products that flow from them—must reflect EM's core commitment to accomplishing environmental cleanup work safely; and OST's commitment to providing technologies that facilitate safe cleanup work.

Prudent application of established science and engineering can help ensure that innovative technologies are significantly safer than existing technologies for workers to operate and maintain. The earlier in the technology development process that potential hazards are identified and controlled, the greater the protection for workers and the cost savings for developers and users.

The Technology Safety Data Sheet (TSDS) is a technology-specific document designed to provide, among other information, the identity and relative risk of safety and health hazards associated with the technology. It can be used as a tool to manage safety and health throughout the technology development and implementation process and provide developers with a method to collect and report hazard information in a form that is understood by the user community. It is intended to be the technology version of the now-familiar Material Safety Data Sheet (MSDS).

The concept of "inherently safer" design should be understood and aggressively pursued by developers. This approach reduces or eliminates hazards as a permanent and inseparable part of the design process, rather than building barriers between workers and hazards, as most engineering controls attempt. The search for inherently safer process options should start early in the development process and never stop.

Time-honored tools of hazard analysis can be effectively applied to innovative technologies. The uniqueness of these technologies does not reduce the value and necessity of using proven system safety techniques such as Job Safety Analyses, Hazard and Operability studies or Failure Mode and Effects Analysis to identify, eliminate or mitigate potential hazards. An important purpose of hazard analysis in the design and development phases is to identify hazards and seek alternative designs or procedures so that the identified hazards will no longer exist in the commercial product.

In 1999-2000, the Environmental Management Advisory Board (EMAB) conducted a review of OST's technology development program with respect to occupational safety and health. This review led to a resolution, adopted in April 2000, in which the EMAB found that the OST program addresses occupational safety and health more comprehensively than other federal agencies with development programs in the remediation technology sector. The EMAB offered eight recommendations for enhancing occupational safety and health in OST's technology development program. These recommendations have been taken into consideration in developing this Policy. They are listed in Appendix A.

On August 22, 2000, a serious accident occurred with a new OST-sponsored remediation technology being demonstrated at the Portsmouth Gaseous Diffusion Plant in Ohio. This accident is a vivid testament to the importance of integrating occupational safety and health deeply and firmly into OST's technology development processes. The lessons learned from this and earlier incidents have helped shape this policy. The primary findings of the Type B Accident Investigation Team are listed in Appendix B. Several aspects of this policy address issues raised in that report:

- The policy requires developers to analyze the hazards of all aspects of new technologies. It provides guidelines for developers to use in doing this, and review of their efforts in peer review and stage gate reviews.
- The policy requires enhanced development and communication of hazard information to workers and contractors, via Technology Safety Data Sheets, more occupational safety and health information in ITSRs, and worker training requirements.
- The policy mandates the establishment of clear lines of responsibility, flowing through all procurement vehicles, for occupational safety and health at all stages in the development process.
- The policy promotes a new level of commitment to occupational safety and health, beginning in the earliest stages of technology development and maintained throughout all stages of the development process.

Additional implications of the report will be evaluated as part of our constant improvement of this policy. Specifically, the accident's Corrective Action Plan will be assessed for implications for this policy.

Section B of this document sets forth five guiding principles for enhanced attention to occupational safety and health in the OST technology development process. Where specific requirements against these principles have been identified, they are also set forth. Section C describes process improvements that are to be implemented in order to realize those principles, and to maintain OST's position of leadership in occupational safety and health in remediation technology development.

B. Guiding Principles

The following principles have been developed to guide the effort to integrate safety and health considerations into the design and deployment of innovative technology.

1. **OST takes responsibility for making its technologies as safe as possible for those who develop and use them; and for assisting decision makers in selecting safer technologies.**

   OST will aggressively pursue: (1) the highest level of safety and health in its science and technology program, making it as safe as possible during conduct of research, development, and demonstration activities; (2) identification and elimination or mitigation of potential operational hazards by impacting design throughout development and demonstration phases; and (3) operator awareness of, and skills to manage, risks and hazards inherent in system use—by including necessary information and training. OST will achieve these through:

   - The requirement of ISM in all levels of proposals, including Technical Task Plan (TTP) language; such provisions are to "flow down" to DOE contractors and subcontractors in relevant documents and practices, with appropriate oversight. Proposers should be required to address such considerations as those found in Section 1.2 or Section 2.2 of Appendix C.
   - Inclusion of a section on occupational safety and health in the initial functional requirements for Technical Task Plans, Requests for Proposals, and other solicitations of requests for financial assistance. This will include the requirement to use inherently safer technologies or processes where possible. Information provided to developers will note that the TSDS will be part of the documentation for the technology where appropriate.
   - The expanded use of Technology Safety Data Sheets (TSDSs) starting in appropriate points in the engineering development phase for maximum benefit; and
   - Communication to technology users about safer technologies using ITSRs; incorporation in the TMS database of TSDSs, ITSRs, and other occupational safety and health-related information; the OST web site; and other information dissemination tools.

- Fostering development of new technologies that, by their use, improve workplace safety and health in comparison to competing technologies.

2. OST's intent is to increase safety and value and minimize bureaucracy.

All efforts will be made to provide greater safety and health protection for workers, and more benefit to the user than cost to the developer. The paperwork burden on developers should be minimized without additional approval layers. Improved S&H will reduce accidents and related costs. It will make technologies more marketable, remove barriers for developers, and reduce their liability. Principles 3 and 4, below, are established specifically with this in mind.

3. OST is committed to assisting technology developers in practical ways to optimize occupational safety and health in its technologies.

Developers will be provided with health and safety information throughout the development process. This will be accomplished by the following:

- Focus Areas will work closely with end-users to define safety and health considerations that should be addressed in technology development.
- TSDSs and operator training requirements will be drafted and updated by the IUOE, based on discussions with the developers, starting as early in development as appropriate. The TSDSs will include appropriate training and emergency response information.
- The American Society of Mechanical Engineers peer reviews will place increased emphasis on occupational safety and health, and will involve individuals with specific expertise in these areas. These will reference, as appropriate, Section 1.3 or 2.3 of Appendix C.
- Occupational safety and health will also be emphasized in Focus Area stage maturity determinations. These determinations will reference, as appropriate, Section 1.3, 2.3 or 3.3 of Appendix C.
- ITSRs will provide expanded information about occupational safety and health, and TSDSs will be included as appendices to ITSRs for which they are available.
- Required operator training will receive increased attention in ITSRs.
- Procurement vehicles will be specific in establishing lines of responsibility for occupational safety and health.
- The requirement for adequate work planning, including hazard analysis, will be emphasized in all field activities.

4. OST will partner with worker organizations to achieve practical safety and health protection.

Specifically, OST will:

- Encourage the involvement of workers who operate innovative technologies in their evaluation; and
- Solicit environmental cleanup worker input on safety and health matters, as is being done with regard to the preparation of TSDSs and with heat stress.

5. **OST will continually improve its safety and health practices.**

   OST will:

   - Seek feedback on the efforts to integrate occupational safety and health, including involvement of S&H subject matter experts, into all phases of technology development and implementation;
   - Have the IUOE formally assess the effectiveness of OST occupational safety and health policies and practices annually to the OST DAS;
   - Monitor indicators such as the number of TSDSs produced and demand for training;
   - Promote active review of lessons learned in the implementation of new technologies at DOE and other sites; and
   - Actively pursue new developments nationally and internationally that may strengthen our approach to occupational safety and health in technology development.

C. Specific Process Enhancements

Integration of Worker Safety and Health Into the Stage-Gate Process

In a February 10, 2000 memorandum, EM-50 laid out the policy, procedures, and guidance for implementation of a streamlined Gate model in the EM Focus Area review process. That memorandum and its attachment provided guidance on the selection, review and tracking of technology maturity in DOE's Environmental Management Science and Technology Program. It describes, in some detail, the components of the OST review system, the purpose and principles of various reviews, and the six gate model process and related criteria. Included are OST Peer Review Core Criteria, Midyear Review Report and supporting documentation, and four tables on technology maturity. Among the seven review criteria are ES&H and risk tolerability. These are primarily applied at the Demonstration and Deployment stage.

As a result of OST's experience with this process, we think it is important to consider occupational safety and health issues throughout the whole technology maturity process. We have used the report of an October, 1998 National Technical Workshop, New Environmental Remediation Technologies: Guidance Criteria for Occupational Safety and Health, dated March 31, 1999, (hereafter Guidelines Reference) as a basic guidance reference in the development of this program. The application of occupational safety and health at the basic research stage is quite different than at the Demonstration and Deployment stage. At the Applied Research stage one needs to consider inherent occupational safety and health concerns as they may influence major research decisions. Guidance on four basic strategies to use is found on page 11 of the

Guidelines Reference. In addition, to help guide these efforts, we have developed guidelines and other tools for developers, which are found in Section 1.2 of Appendix C.

As the technology begins to mature from applied research into the exploratory development stage, significant occupational safety and health effort is required. Checklists and other tools for developers' use at this stage are described in Section 2.2 of Appendix C.

Over the past five years, the International Union of Operating Engineers has developed over 50 Technology Safety Data Sheets (TSDSs) on OST-sponsored technologies. A further description of TSDSs is found in Section 2.2.4 and Appendix E of the Guideline Reference. The basis for preparing a TSDS is the hazard analysis. This can be accomplished in many ways using many different proven methods or "tools." Some of the common methods used for hazard analysis include what-if/checklist, Hazards and Operability Study, Failure Mode and Effects Analysis, and Fault Tree Analysis. See Appendices B, C, and D of the Guideline Reference for more details on hazard analysis.

The TSDS approach has been recently piloted for application at earlier stage levels. The results of the pilot show that the TSDS development process can begin by Gate 4, Ready for Engineering Development, and can be continuously improved up to Deployment. As the technology gets to the demonstration stage, technology-specific emergency response and worker training information is also generated. The scope of these elements is found in Appendices F, G, and H of the Guideline Reference. All of this information needs to be available at the start of the Demonstration Stage.

Consideration of Safety and Health in the Peer Review Process

Peer reviews are an important element in the entire development cycle from project selection to demonstration. Occupational safety and health issues will be considered in this process. Early consideration of occupational safety and health should result in technologies that have fewer safety and health issues.

The criteria for ASME peer review will include a generic list of OSH questions or criteria such as:

- What are the risks associated with the proposed process?
- Is the proposed technology inherently as safe or safer than the baseline technology?
- Are there explosive, carcinogenic or otherwise hazardous chemicals?
- Have the developers considered these risks, and proposed adequate safeguards?

Criteria for use in peer review are found in Section 1.3 of Appendix C.   Criteria for review of proposals which enter at the development stage can be found in Section 2.3 of Appendix C.

The ASME peer review panel will include at least one person who is qualified to evaluate the merits of the proposals from an occupational safety and health perspective. The occupational safety and health reviewer's qualifications must be matched with the particular technology being proposed.

Consideration of Safety and Health In the Mid-Year Review Process

Projects are reviewed annually for technical progress and relevance as part of the Mid-Year Review Process. Occupational safety and health has in the past been included in this review process and documentation. This is being upgraded and strengthened as described above. Greater emphasis on occupational safety and health issues will be verified during the mid-year review process to ensure selection and development of technologies that have optimal occupational safety and health characteristics. Focus Areas will be expected to note in their Mid-Year Review Reports progress of technologies on safety and health related to the questions provided in Section 1.3, 2.3 or 3.3 of Appendix C.

The Guidance for FY-2001 Mid-Year Review Process will include a requirement for a TSDS for a few first-priority technologies as determined by OST's implementation plan for TSDS, in coordination with Focus Area management. The TSDS will be placed in the Focus Area documentation files. In FY-2002 this requirement will extend to all technologies reaching Gate 4 for which a TSDS is determined to be appropriate.

Inclusion of TSDSs in ITSRs and TMS

Innovative Technology Summary Reports (ITSRs) for all new technologies will provide more information on occupational safety and health than has typically been the case in the past, and will include TSDSs where these are available. The Technology Management Summary (TMS) database will also include TSDSs on all technologies for which they are available. Related information about occupational safety and health in innovative technology development will soon be available on the OST Website.

Summary

This complete process is illustrated in Figure 1, Occupational Safety and Health Requirements for Stage-Gate Process as a Function of Technology Maturity. Further description of the guidance for program implementation based on the Guidelines Reference is found in Appendix C.

D. Consideration of Future Safety and Health Issues

OST will actively pursue new information that will help us to sustain continuous improvement in the integration of occupational safety and health in our technology development program. OST will pursue new developments within the DOE community; as well as within the broader occupational safety and health and technology development communities nationally and internationally (particularly in the European Community). As new safety and health information is identified, OST will draw upon it as appropriate to enhance our policy and program. In particular, OST will be watchful for particular worker safety and health concerns which may lend themselves to intervention through OST's technology development processes.

E. Periodic Updates of This Policy

This policy will be reviewed and updated as needed after approximately one year.

An OST-sponsored workshop October 23-25, 2000 in Beaver, West Virginia addressed issues related to capturing occupational safety and health compliance costs of environmental remediation technologies. The results of this workshop, when available, will be considered for incorporation into a revision of this policy.

The August 22, 2000 accident at the Portsmouth Gaseous Diffusion Plant and the resulting Type B Accident Investigation report have raised important issues relating to contract language. Further reviews and evaluations of the impact of the accident report are planned during the first year of this policy. These will be reflected as appropriate in a future revision.

Figure 1:
Occupational Safety and Health Requirements for Stage-Gate Process as a Function of Technology Maturity

Gate Number		0	2	5	6
Safety and Health Actvity	**Idea**	**Research**	**Development**	**Demonstration**	**Deployment**
User OS&H Needs	As Appropriate (1)				
OST Peer Reviews (2)	As Appropriate (1)		**Essential**	**Essential**	
Mid-year Reviews (3)	**Essential** →	→	→	→	→
Developer-- OS&H Checklist		**Essential** →	→	→	→
Developer-- OS&H TSDS (4)			**Essential** →	→	→
Emergency Response (5)				**Essential**	
Training (5)				**Essential**	
ITSR Input				**Essential**	
TMS Input (4)		**Essential** →	→	→	→

1. Safety and health considerations are graded so that laboratory considerations are applied at the Idea and Research stages. As engineering design develops and a technology goes from early Development to Deployment the safety and health programs become more applied to engineering and eventual deployment.
2. Normally, ASME conducts technical peer reviews for OST at the request of the Focus Areas. Other peer reviews may be conducted by the Focus Areas which do not require ASME. OST requires technical peer reviews for all ongoing projects at least every three years and at two key decision points. (Gates 2 and 5)
3. Stage Gate review process will include S&H considerations. This can be accomplished by various arrangements like using the IUOE for D&D Activities.
4. TSDS development and TMS input are continuously improved up to deployment.
5. Emergency response and training will be part of TSDS and be technology specific for generic site use.

Appendix A

Recommendations of the Environmental Management Advisory Board Regarding Occupational Safety and Health in the EM-OST Technology Development Program April 14, 2000

1. Provide effective, usable safety and health guidelines/ checklist to the developer community.

2. Provide guidance for consideration of safety and health matters in the ASME peer review process.

3. Develop more detailed guidelines for consideration of safety and health in the Stage Gate procedure.

4. Require a Technology Safety Data Sheet (TSDS) for every technology at mid-stage review.

5. Include occupational health and safety compliance costs in technology cost-performance data.

6. Identification of “safer” technologies; dissemination of that information.

7. Initiate a heat stress management development program.

8. Develop specific contract language that promotes use and/or implementation of new technologies. *

*This recommendation was formally deferred by EMAB on September 28, 2000, pending development of amplifying comments by EMAB.

Appendix B

Conclusions of Type B Investigation, Accident at Portsmouth Gaseous Diffusion Plant August 22, 2000

On August 22, 2000, an accident occurred at the U. S. Department of Energy (DOE) Portsmouth Gaseous Diffusion Plant (PORTS) located in Piketon, Ohio. An employee of the IT Corporation (IT) working on an Environmental Management (EM) Technology Deployment Project received serious burns from a violent chemical reaction.

On August 23, 2000, the Manager, Oak Ridge Operations (DOE ORO), chartered a Type B Accident Investigation Board to investigate the accident. The Board completed the investigation in September 2000. Their report was presented to the DOE ORO Manager and was approved October 20, 2000.

The Board concluded that this accident and the resulting injuries were preventable. This accident highlighted deficiencies in numerous aspects of safety management and emergency preparedness for the project.

The direct cause of the accident was the introduction of crystalline sodium thiosulfate into a five-gallon bucket containing concentrated sodium permanganate solution. Neither the UT-Battelle and IT line managers who were responsible for the workers' safety nor the BJC readiness review team adequately understood or analyzed the hazards of the job site. Therefore, they did not assure that adequate hazard controls were in place.

The Board identified four root causes for the accident:

- UT-Battelle, BJC, and IT management failed to analyze the hazards for all field activities. This failure resulted in inadequate development and implementation of control measures for and knowledge of the potential hazards.

- UT-Battelle, BJC, IT, and the IT subcontractors' project personnel failed to implement the hazard controls and requirements stated in the project documents.

- DOE ORO, UT-Battelle, BJC, and IT management did not establish clear roles and responsibilities for the planning, execution, and oversight of the project.

- DOE ORO, UT-Battelle, BJC, and IT management did not establish or ensure a safety culture that implements integrated safety management and encourages personnel to stop and re-enter the analysis phase when a change or unexpected condition arises.

On September 28, 2000, the President of Bechtel Jacobs Company (BJC) wrote to the DOE Oak Ridge Operations Office:

1. No technology demonstration, or work involving multiple DOE prime contractors, will be performed without clear roles and responsibilities defined. Specifically, if BJC is to be responsible for the work and the safety thereof, BJC must hold contractual authority with the performing entity. There will be no split responsibility/accountability for safety in work execution.

2. I will order a stand down for all current work involving multiple entities with split responsibility/accountability for safety in work execution until roles and responsibilities are defined and contractual accountability is clearly established.

APPENDIX C

Guidelines and Tools for Use by Technology Developers and Reviewers by Stage Gate

The information in this Appendix has been distilled from several parts of Interim Final Guidelines-- New Environmental Technologies: Guidance Criteria for Occupational Safety and Health, March 31, 1999. The source document was a product of a National Technical Workshop held October 14-16, 1998 in Miami, Florida, sponsored in part by the U.S. Department of Energy. It provides useful guidance and tools both for technology developers and for reviewers of their proposals and progress, in the research, development and demonstration stages.

1.0 RESEARCH STAGE

1.1 Background

At this early stage of technology development there is only a general framework of what the technology will look like, often lacking dimensions, throughput capacity, and most other major parameters of the final technology. At the research stage, the main intention is to prove that a particular process will work at a benchtop scale.

Consequently, most of the potential safety hazards may be impossible to detect at this stage. Health-related hazards will be much more visible, however. It is clearly not too early for the designer to consider the principle of inherent safety during the research. Hendershot defined a process as inherently safer if it reduces or eliminates hazards associated with materials and operations used in the process, and this reduction or elimination is a permanent and inseparable part of the process technology.[1]

Inherent safety is also referred to as "primary prevention" because it relies on the development and deployment of technologies that prevent the *possibility* of an accident. By comparison, "secondary prevention" reduces the *probability* of an accident, and "mitigation" and emergency responses seek to reduce the *seriousness* of injuries, property damage, and environmental damage resulting from accidents.[2]

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[1] Hendershot, D. C. (1997). Inherently safer chemical process design. J. Loss Prev. Process Ind., 10. No.3. 151-57.

[2] Ashford, N. A. (1997, March-June). Industrial safety: The neglected issue in industrial ecology. Journal of Cleaner Production,5,

1.2 Tools for developers

1.2.1 Preliminary Hazard Analysis

A Preliminary Hazard Analysis (PHA) is a general, qualitative study that provides a rough estimate of potential hazards and ways to correct them. As part of the U.S. Military Standard System Safety Program, a PHA focuses on sources of energy for the system and on hazardous materials that might adversely affect the system or environment.[3] The results of a PHA can be summarized in the form of a table in which potential hazards are identified along with their cause and effects. For each hazard a preliminary means of control must be identified. At this stage of development, elimination of the hazard is much easier, although engineering controls can also be identified.

An example of a summary table is included.

Hazard	Cause	Major Effects	Preventive or Corrective Measures

1.2.2 General guidelines

Developers should consult the following set of general design requirements for all that apply to the technology at the research stage[4]. These simple principles should be consulted throughout the design and development of the technology.

1. Avoid introducing the hazard: prevent buildup of the form of energy or hazardous materials.
   - Avoid producing or manufacturing the energy or the hazardous materials;
   - Use material handling equipment rather than manual means; and
   - Don't elevate persons or objects.

2. Limit the amount of energy or hazardous material.
   - Seek ways to reduce actual or potential energy input;
   - Use the minimum energy or material for the task (voltage, pressure, chemicals, fuel storage, heights);
   - Consider smaller weights in material handling;
   - Store hazardous materials in smaller containers; and
   - Remove unneeded objects from overhead surfaces.

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[3] Kavianian, H.R. & Wentz, C.A. (1990). Occupational and environmental safety engineering and management. New York: Van Nostrand Reinhold. 257.

[4] Christensen, W. & Manuele F. (1999) Safety Through Design. Chicago: National Safety Council, 13-14.

3. Substitute, using the less hazardous.
   - Substitute a safer substance for a more hazardous one: when hazardous materials must be used, select those with the least risk throughout the system's life-cycle;
   - Replace hazardous operations with less hazardous operations;
   - Use designs needing less maintenance; and
   - Use designs that are easier to maintain, considering human factors.

4. Prevent unwanted energy or hazardous material buildup.
   - Provide appropriate signals and controls;
   - Use regulators, governors, and limit controls;
   - Provide the required redundancy;
   - Control accumulation of dusts, vapors, mists, and so forth;
   - Minimize storage to prevent excessive energy or hazardous material buildup; and
   - Reduce operating speed (processes, equipment, vehicles).

5. Prevent unwanted energy or hazardous material release: consider all forms of energy – mechanical, electrical, chemical, thermal, and radiation.
   - Design containment vessels, structures, elevators, material handling equipment to appropriate safety factors;
   - Consider the unexpected in the design process, to include avoiding the wrong input
   - Protect fail-safe interlocks on equipment, doors, valves;
   - Install railings on elevations;
   - Provide non-slip working surfaces; and
   - Control traffic to avoid collisions.

6. Slow down the release of energy or hazardous material.
   - Provide safety and bleed off valves;
   - Reduce the burning rate (using an inhibitor);
   - Reduce road grade; and
   - Provide error-forgiving road margins.

7. Separate in space or time, or both, the release of energy or hazardous materials from that which is exposed to harm.
   - Isolate hazardous substances, components, and operations from other activities, areas, and incompatible materials, and from personnel;
   - Locate equipment so that access during operations, maintenance, repair, or adjustment minimizes personnel exposure (e.g., hazardous chemicals, high voltage, electromagnetic radiation, cutting edges);
   - Arrange remote controls for hazardous operations;

- Eliminate two-way traffic;
- Separate vehicle from pedestrian traffic; and
- Provide warning systems and time delays.

8. Interpose barriers to protect the people, property, or the environment exposed to an unwanted energy or hazardous material release.
   - Insulation on electrical wiring;
   - Guards on machines, enclosures, fences;
   - Shock absorbers;
   - Personal protective equipment;
   - Directed venting;
   - Walls and shields;
   - Noise controls; and
   - Safety nets.

9. Modify the shock concentrating surfaces.
   - Padding low overheads;
   - Rounded corners; and
   - Ergonomically designed tools.

1.3 Criteria for reviewers

Reviewers of proposed basic research should include the following safety and health criteria in the review process:

1. Will the operators of the technology be at reduced risk of health hazards from the process compared to the baseline technology that will be replaced? For safety hazards?
2. Will maintenance workers who service the technology be at reduced risk from health hazards? From safety hazards?
3. Have occupational health and safety issues been adequately addressed?
4. If one or more chemicals will be used in the process, has the developer clearly demonstrated in writing that he or she has fully explored the health and safety risks? Are MSDSs available for the chemicals?
5. What evidence is there that the principles of “inherently safer” design have been considered by the developer?
6. Is there any evidence that safety and health professionals were consulted during the initial research and proposal generation?
7. Is there any evidence that potential purchasers and users of the technology have been consulted and responded favorably to the idea?

8. Has the project team collected sufficient data to respond to regulatory concerns?
9. Is it clear that the project team will have access to sufficient safety and health expertise as the technology is developed and demonstrated?
10. Is their any history of workers being hurt from technologies similar to the one being proposed?

2.0 DEVELOPMENT STAGE

2.1 Background

During the development of the technology, decisions made by the designers will greatly affect the workers who will eventually operate and maintain the equipment. Every system of the technology should be sufficiently robust before the demonstration phase for the developer to conduct an extensive safety analysis. Technologies that move from the development phase to demonstration without significant safety analyses may pose serious risk to workers at the demonstration site.

There are an abundance of analytical tools and techniques that a developer can use during the development stage. The choice of which safety analysis or combination of analyses to employ should be used depends on the following factors.[5]

- Complexity of the technology
- Scope of the planned evaluation
- Experience of the developer with similar designs
- Availability of data
- Originality of the design
- Availability of industry standards and codes

2.2 Tools for developers

2.2.1 Checklists

Checklists are most helpful in repetitive design tasks or operations where product variation is small. Safety checklists are useful because creating them requires a safety analysis. The resulting checklist is tailored to the particular design. This same checklist can be used for subsequent designs if strong similarities exist between the designs. Safety professionals rarely use a checklist as the sole tool for evaluating a technology or process but prefer to combine the checklist with other analytical tools such as a What-If Analysis.

There are many checklists that are available at no cost to developers. The following checklists are recommended specifically for developers of new technologies.

[5] Main, B.W. (1996, Sept.). Safer by design. Machine Design. 104.

SOURCE	DESCRIPTION	LOCATION
OSHA	Machine Guarding	Http://www.osha-slc.gov/Publications/Mach_SafeGuard/checklist.html
OSHA	Robotic technologies	http://www.osha-slc.gov/SLTC/robotics/index.html
U.S. Navy	The Navy has created a template for writing a Technology Safety Data Sheet for new technologies	Http://www.navfac-safety.navy.mil/tsds.htm
NIOSH	NIOSH has several ergonomic checklists included in the Elements of Ergonomics Programs (NIOSH 97-117)	http://www.cdc.gov/niosh/ephome2.html
Operating Engineers National Hazmat Program	The OENHP has created an extensive set of checklists specifically for developers of new technologies covering: - Pre-startup - Process Safety Information - Human Factors engineering - Process Hazard Analysis - Emergency response	Available electronically at http://ww.iuoeiettc.org or in paper: "Guidelines for Assessment Protocol Development for Type II Innovative Environmental Remediation Technologies" available by calling 304-253-8674.
Oklahoma University	An impressive resource list that contains guidance materials.	http://www.pp.okstate.edu/ehs/LINKS/topindx.htm
Mary Kay O'Connor Process Safety Center at Texas AMU	The Process Safety Center has developed extensive resources on chemical process safety with many links to other sites.	http://mkopsc.tamu.edu/

2.2.2 System safety analyses

TYPE OF ANALYSIS	DESCRIPTION	RECOMMENDATION
What-If Analysis	This free-form method involves a team identifying hazards associated with a technology by asking questions that start with "What-If…" The examination must systematically review each operation and system, identify what adverse consequences can occur, and how to prevent or mitigate them.	Every technology can benefit from this type of analysis. What-if analyses are usually combined with checklists to couple the brainstorming advantages of What-if analyses with the comprehensiveness of checklists.
Failure Modes and	FMEA is a systematic method by	This should be performed by

TYPE OF ANALYSIS	DESCRIPTION	RECOMMENDATION
Effects Analysis (FMEA)	which equipment and system failures and resulting effects are determined.	a team. There are software programs available to expedite the process. FMEA does not examine the results of human errors as thoroughly as other methods. The criticality of each failure should be ranked to prioritize corrective actions.
Hazard and Operability Study (HAZOP)	HAZOP is a systematic review of each part of a process by using guide words such as “no” “high” “low” to identify possible situations that could lead to negative events. Corrective actions are included.	HAZOPs must be performed with teams representing each of the key disciplines.

2.3 Criteria for reviewers

Reviewers of technologies to be developed based on successful research should use the following criteria to judge the efforts of the developer to consider safety and health.

1. Has a safety analysis of the technology been performed?
2. What type of analyses were performed and were they appropriate to the complexity of the technology?
3. Were the analyses conducted by teams with necessary expertise?
4. Were any of the analyses conducted by an independent organization or reviewed by an independent organization?
5. Did the analyses reveal any potentially serious hazards that could not be corrected through engineering changes?
6. Does the technology rely heavily on work practices and personal protective equipment to protect the operator and maintenance personnel?
7. Were any measurements or estimates made for noise levels or exposures to chemical vapors, dusts, or radiation?
8. Were the results acceptable?
9. Do the cleanup capabilities of the technology appear sufficiently important in comparison to the residual risks remaining for workers to warrant going forward with a demonstration of the technology.

3.0 DEMONSTRATION STAGE

3.1 Background

The demonstration stage is the most important for ensuring that the technology can really accomplish in the field what was previously demonstrated in the laboratory and in pilot scale. This is the stage at which the hypothesized throughput of the technology is measured against the rigors of operating in a real field environment. This is also the stage at which additional hazards may become evident due to the need for scaling up the previous versions of the technology. Greater temperatures or pressures may be needed; elevated work stations may be created where none were needed for pilot scale versions.

3.2 Tools for developers

Developers need to continue to perform earlier safety analyses to ensure that additional hazards have not been added as the systems grow in scale to meet the needs of the field demonstration. The developers also need to institute a Management of Change (MOC) procedure for any systems that are substantially altered after the original safety analyses. An example of an MOC is found in the OENHP guidance document, "Guidelines for Assessment Protocol Development for Type II Innovative Environmental Remediation Technologies (Appendix S). Most importantly at this stage, a Pre-startup evaluation must be conducted prior to formally commencing the demonstration. An example of a Pre-Startup checklist is found in Appendix A of the OENHP document. The developer should also produce a Health and Safety Plan (HASP) for the demonstration process that meets the requirements of OSHA's Hazardous Waste Operations and Emergency Response standard (29 CFR 1910.120). Part of that plan should include the types of Industrial Hygiene measurements that will be collected during the demonstration and the type of personal protective equipment that workers will wear during the testing.

3.3 Criteria for reviewers

Reviewers of a demonstration project should consider the following criteria:

1. Has the developer documented safety evaluations of changes to the initial design?
2. How rigorous is the pre-startup plans of the developer?
3. Is there a written HASP for the project?
4. How adequate is the HASP?
5. Are there plans for safety and health professionals to regularly monitor the process during the demonstration?

4.0 GUIDELINES FOR SAFETY AND HEALTH PROGRAMS IN INNOVATIVE TECHNOLOGY DEVELOPMENT

4.1 Safety and Health Hazards

This guidance centers on hazard recognition, analysis, and mitigation. This is the same focus on which the technology user bases the workplace safety and health program and the site-specific safety and health plan. Identifying and mitigating hazards represent the core activities in OSHA's Hazardous Waste Operations and Emergency Response regulation as well as the Process Safety Management regulation. Additionally, the application of the Systematic Approach to Training is founded upon hazard identification as the launch point. In meeting these Guidelines, therefore, the technology developer is providing the basis upon which several additional needs and requirements can be met.

4.2 Emergency Preparedness

Emergency Preparedness, among the other requirements within OSHA's HAZWOPER regulation, is the most frequently cited deficiency by OSHA. Emergency preparedness issues are, likewise, generally not a matter commanding the attention of the technology developer. It is important to note that *all* workplaces are required to have an emergency response or emergency action plan. In workplaces employing environmental remediation technologies, the need to adequately address emergency potential and the response actions needed should an emergency arise is particularly acute.

This guidance is intended to aid the developer in identifying and communicating the technology-specific information needed by the user to meet emergency preparedness requirements. The developer is in a unique position to best understand the emergency situations that could develop and the best methods to prevent, control, or mitigate such occurrences. The Emergency Response Data Sheet (ERDS) is the vehicle through which relevant information can be transmitted to the user and emergency response community. For a description of ERDSs and their application see Pages 17-30 and Appendices F and G of the Guidelines Reference.

4.3 Training

This guidance assumes that environmental remediation technologies are deployed in environments in which the user of the technology must comply with the OSHA Hazardous Waste Operations and Emergency Response standard or the State/owner equivalent. HAZWOPER generally requires that the user assures that all employees receive training that includes two basic elements important to the developer.

1. <u>Core HAZWOPER Training</u>. This is basic training considered to be conducted off-site and to address the HAZWOPER category within which the employee will work, such as clean up or an RCRA-TSD site.

2. Site-Specific Training. This training is intended to achieve two objectives: transition new employees into the hazardous work to confirm that the core training was adequate and to provide training related to the site-specific hazards as well as the other aspects of the site-specific safety and health plan.

It is NOT the intent of this guidance to suggest that the developer provide training program materials with the technology that meet or repeat the core requirements. Rather, the technology-specific training materials should address those aspects of the technology that are relevant to operators and maintenance personnel as a useful supplement to the site-specific training program. Absent the technology-specific training materials from the developer, the technology user is required to develop an appropriate training program to ensure the safe operation and maintenance of the technology. For a description of technology-specific training needs see Pages 31-33 and Appendix H of the Guidelines Reference.

Office of Environmental Management
Response to EMAB Recommendations and Action Plan
for Enhancing Worker Safety and Health
in EM's Technology Development Processes
January 2001

Introduction

The EM cleanup-stewardship mission is based on the principle that we must protect our workers, the public, and the environment. Assistant Secretary Carolyn Huntoon has stated: "First and foremost, we must protect our workers, the public and the environment. 'Safety First' is more than just a slogan - it must be at the heart of everything we do. I want a focus on safety to become the norm at all of our sites and with all of our employees -contractor or Federal." (http://www.em.doe.gov/huntoon.html)

On April 17, 2000, the Environmental Management Advisory Board (EMAB) transmitted to Assistant Secretary Carolyn Huntoon a "Resolution on the Consideration of Occupational Safety and Health in the EM-OST Technology Developmental Program." The EMAB found that "the OST Program addresses occupational safety and health more comprehensively than other federal agencies with development programs in the remediation technology sector." The EMAB also recommended eight actions to further improve OST's performance in this area. Dr. Huntoon directed the Office of Science and Technology and the Office of Safety, Health and Security (OSHS) to work closely in addressing the recommendations in that Resolution.

A new EM policy statement issued in January 2001 describes in detail how worker safety and health is to be promoted during the development and deployment of innovative environmental cleanup technologies. The action plan presented below shows how EM is completing its response to each of the EMAB recommendations. It also notes the success criteria for each recommended action. A chart at the end of this document shows the expected time frame for implementing each action.

On August 22, 2000, a serious accident occurred with a new OST-sponsored remediation technology being demonstrated at the Portsmouth Gaseous Diffusion Plant in Ohio. This accident and the report of the resulting investigation provide strong evidence of the need to improve the way occupational safety and health is addressed in EM's technology development processes. Several of the initiatives described herein, in response to EMAB recommendations, can be expected to reduce the likelihood and/or severity of another accident such as occurred at Portsmouth. In addition, the January 2001 EM policy statement sets forth health and safety improvements in response to the accident investigation report. In particular, we note the importance of procurement language that establishes clear lines of responsibility for occupational safety and health.

Plan

1. **Recommendation:** Provide effective, usable safety and health guidelines/ checklist to the developer community.

   New occupational safety and health guidelines and checklist are found in Appendix C to the EM policy statement on occupational safety and health in EM's technology development processes, issued January 2001. These will be distributed to current and prospective technology developers, including as part of solicitations and technical task plans. The goal is to help technology developers understand the role that occupational safety and health considerations must play throughout their research and development efforts. OST intends, also, to provide developers with information and support needed to enable them to bring occupational safety and health considerations into their technology development work at an early stage, and to maintain attention to OSH throughout the development process. Among the information and support will be the new guidelines described above, and support from the IUOE in development of Technology Safety Data Sheets (TSDS). In addition, methods will be pursued to achieve end-user definitions of site needs with respect to occupational safety and health considerations for developers.

   What Constitutes Success: Feedback from ASME peer reviewers, Focus Areas, and the IUOE will tell us how well this guidance to developers is reflected in their submissions and other performance. The EM-50 Safety and Health Program Manager will monitor such feedback and provide periodic assessments to management.

2. **Recommendation:** Provide guidance for consideration of safety and health matters in the ASME peer review process.

   The EM policy document provides guidance for consideration of safety and health in ASME peer review. This is augmented by the related guidelines/checklist document in Appendix C to the policy document. This guidance is consistent with that given to developers. ASME will be asked to assign individuals with appropriate expertise in occupational safety and health to participate in the peer reviews. These policies will be reflected in a revision of the OST document "Tracking Technology Maturity in DOE's Environmental Management Science and Technology Program," which sets out peer review requirements.

   What Constitutes Success: Feedback from peer reviewers as to usefulness of the guidance; and evidence of how the consideration of occupational safety and health in the peer review process has influenced outcomes. The EM-50 Safety and Health Program Manager will monitor such feedback and provide periodic assessments to management.

3. **Recommendation:** Develop more detailed guidelines for consideration of safety and health in the Stage Gate procedure.

   The EM policy document provides guidance for consideration of safety and health in Focus Area stage maturity determinations. This is augmented by the guidelines/checklists in Appendix C to the policy document. These guidelines are consistent with the guidance given to developers, and that used in the ASME peer review process. These changes will be reflected in a revision of the OST document "Tracking Technology Maturity in DOE's Environmental Management Science and Technology Program."

What Constitutes Success: Feedback from Focus Areas as to usefulness of the guidance; and evidence of how the consideration of occupational safety and health in the mid-year reviews has influenced outcomes. The EM-50 Safety and Health Program Manager will monitor such feedback and provide periodic assessments to management.

4. **Recommendation:** Require a Technology Safety Data Sheet (TSDS) for every technology at mid-stage review.

OST has, for the past five years, working with the International Union of Operating Engineers, provided for the production by IUOE of Technology Safety Data Sheets (TSDS) for technologies reaching the demonstration phase of development. The value of these TSDSs has been clearly established. It is recognized that not every OST innovative technology is appropriate for developing a TSDS. At OST's request, the IUOE recently conducted three pilots to test the value of requiring TSDSs at mid-stage review. These pilots were completed, and IUOE submitted its report on October 3, 2000. Based on this report, OST will work with the Focus Areas to identify resources and develop a phased implementation plan for TSDS development by Gate 4, Engineering Development. Until appropriate TSDSs have been prepared on backlog technologies and a standard approach is in place, OST will ask the IUOE to assist the Focus Areas in identifying those technologies most needing TSDSs. (Because so many late-stage technologies still need TSDSs, and these are a priority, it may take some time to get TSDSs in place for many mid-stage technologies.) The results of these discussions will be incorporated into a future revision of the EM policy document on occupational safety and health in the science and technology program.

What Constitutes Success: The phased implementation plan will divide OST's developmental technologies into two levels of priority with respect to the importance of the TSDS to operations. Success will be measured in terms of how many of our first-priority technologies have TSDSs at the 2001 mid-year review; and how many of all technologies reaching mid-stage review, for which TSDSs are appropriate, have TSDSs at the 2002 mid-year review.

5. **Recommendation:** Include occupational health and safety compliance costs in technology cost-performance data.

When competing technologies are available to address an environmental remediation challenge, the inherently safer technology may be disadvantaged if all of the safety and health-related costs of implementing other technologies are not fully captured. The IUOE hosted a workshop in Beaver, WV, October 23-25, 2000, to consider this issue. As a result of the workshop, a report will be published outlining a consensus approach to including safety and health risk and compliance costs in technology cost-performance data. The consensus approach will be considered for revisions to the EM policy document.

What Constitutes Success: Revisions will be made to the EM policy document based on EM's consideration of the report from the Beaver workshop.

6. **Recommendation:** Identification of "safer" technologies; dissemination of that information.

OST will approach this in two parts, at least initially: identification of "safer" technologies; and communication of information to end-users about the occupational safety and health implications of new technologies.

<u>Identification of "Safer" Technologies</u>

OST is seeking a better understanding of what others—particularly the European Union—are doing in this area, to see what lessons can be learned and incorporated into OST's approach. To that end, OST plans to meet soon with a representative of the European Union, and is collecting further information on their approach to consideration of the safety and health implications of new technologies. OST will also look at work done by a committee of the American National Standards Institute and others, to help inform our efforts. Based on the information collected, OST will identify a path forward.

What Constitutes Success: Our first success will occur when we have an agreed-upon path forward on this point that is informed by the lessons we learn from the EU, ANSI and others.

<u>Communicate Information on the Safety and Health Implications of New Technologies to End-Users</u>

OST is beginning by communicating information about occupational safety and health considerations in innovative technologies to end users, who will ultimately make decisions based on their needs and priorities. This communication is occurring through the following steps:

- Improving the information on occupational safety and health in Innovative Technology Summary Reports (ITSRs)
- Including TSDSs in ITSRs where applicable
- Posting all available TSDSs in the Technology Management System (TMS)
- Posting information on the OST web site about occupational safety and health in innovative technologies and about "safer" technologies
- Sponsoring a poster session (by IUOE) on safety and health in new cleanup technologies at the TIE workshop in November, 2000
- Writing an article (IUOE) on TSDSs for the November TIE Quarterly newsletter

OST is considering how to establish an innovative recognition program to draw attention to technologies that have been developed with particular attention to inherently safer design.

What Constitutes Success: Information provided by OST will play a role in the selection of new remediation technologies by end-users.

7. **Recommendation:** Initiate a heat stress management development program.

Heat stress is a significant safety and health factor in much environmental remediation activity. Recognizing this, OST and EM-5 have asked the International Union of Operating Engineers to gather input from actual cleanup workers, to identify practical needs for a heat stress management development program. With that practical information about needs in hand, OST and EM-5 will circulate a concept paper to EM 20, 30, 40, Focus Areas and others for comment. EM's further course of action will flow from that concept paper.

In the course of OST's consideration of this recommendation, it has come to our attention that other occupational safety and health issues may be identified in the future that may warrant similar treatment.

It has also been informally suggested by others than EMAB that OST review occupational safety and health evaluations and analyses performed at DOE sites to identify other safety and health issues that are being repeatedly mitigated through careful planning of work. These issues may present good targets for intervention through OST technology development.

What Constitutes Success: The first level of success will be demonstrated by a report from IUOE outlining needs, as identified by cleanup workers, for a heat stress management development program. Other levels of success will depend on the outcome of that report; and on other occupational safety and health issues (for example, noise and cold stress) that may be identified as meriting similar attention.

8. **Recommendation:** Develop specific contract language that promotes use and/or implementation of new technologies.

At the formal request of EMAB staff (September 28, 2000), work on this recommendation will be suspended pending further consideration by the Contracting Subcommittee of the EMAB.

Closely related to this is the importance of establishing clear contractual lines of responsibility for occupational safety and health, especially when new technologies are demonstrated or deployed in the field under different contract mechanisms. The investigation report on the August 22, 2000 accident at the Portsmouth Gaseous Diffusion Plant found, in part, that management of the various parties involved did not establish clear roles and responsibilities for the planning, execution, and oversight of the project. OST is working to ensure that all procurement vehicles within its purview are explicit in assigning responsibilities for worker safety and health and seeing that these responsibilities flow down appropriately through all contractual levels. This requirement is reflected in the EM policy document on occupational safety and health in the science and technology program.

Timetable for Action Plan

ID	Task Name	Date
1	**Guidelines for Developers**	
2	To Focus Areas for Comment	10/20
3	Comments from Focus Areas	11/10
4	Finalize in policy	11/15
5	Issue to current developers	02/28
6	Incorporate into RFPs	02/28
7	**Guidance for ASME Peer Review**	
8	To Focus Areas for Comment	10/20
9	Comments from Focus Areas	11/10
10	Finalize in policy	11/15
11	Provide to ASME Panels	02/28
12	OSH experts on ASME Panels	01/31
13	**Guidelines for Stage Gate Review**	
14	To Focus Areas for Comment	10/20
15	Comments from Focus Areas	11/10
16	Finalize in policy	11/15
17	Apply at 2001 Mid-year Review	02/28
18	**TSDSs Reqs. at Mid-Stage**	
19	Complete three pilots	10/30
20	Identify resource needs	11/30
21	Finalize in policy	11/15
22	Dev. Phased Implementation Plan	01/02
23	First group TSDSs ready	02/28
24	Second group TSDSs ready	02/28
25	**OSH Costs in Tech. Cost-Perf. Review**	
26	Workshop	10/30
27	Workshop report	01/31
28	Modify policy as appropriate	10/01
29	**Safer Technologies Information**	
30	Finalize in policy	11/15
31	TSDSs in ITSRs (begin)	11/30
32	TSDSs in TMS	04/02
33	Add S&H section to OST web site	01/02
34	Study EU approach	10/30
35	Finalize in policy	11/15
36	TIE Workshop	11/30
37	Present at ICEM '01	10/04
38	Modify policy as appropriate	10/01
39	**Heat Stress**	
40	IUOE report on worker needs	01/30
41	Concept paper circulated	02/28
42	Concurrence from EM-5, 20, 30, 40	04/02
43	Develop next steps	04/02
44	**Contract Language**	
45	EMAB recommendation pending	09/28
46	Evaluate accident report	04/20
47	Adjust procurement vehicle language	09/28
48	**Annual update of policy**	
49	Evaluate accident report	04/20
50	Revise based on Acc. Rpt. Evaluation	09/28