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DOE/ET/13650-10

SAFETY ANALYSIS REVIEW
TERMS OF REFERENCE

March 1981

Prepared for
Office of Assistant Secretary for Fossil Energy
U.S. Department of Energy
Under
Contract DE-AM01-13650.002

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by
Timothy Hurley

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ABSTRACT

This document has been prepared to suggest procedures and items for consideration in the review of safety analysis prepared on DOE fossil energy conversion and technology development projects. It is not intended to reflect official DOE policy. It does, however, provide a basis for consistency in conducting reviews, especially with regard to interpreting levels of risk. Since many of the persons assigned to review panels are not expected to be safety analysts but specialists in related fields such as industrial hygiene and environmental science, this document is intended to provide general terms of reference to facilitate review procedures.

SAFETY ANALYSIS REVIEW

TERMS OF REFERENCE

INTRODUCTION

Because of the widely varying nature of its projects, FE cannot specify firm procedures for performing Safety Analyses Reviews. Each review panel should, at the outset of its considerations, prepare its own "review terms of reference" for conducting that particular review. The review terms of reference should include such administrative conditions as time limits for preparing individual commentaries, general format for written comments and procedural matters. Specific and general criteria to be applied in the review process should also be defined prior to initiating the review. An Executive Secretariat should assist in developing these procedures if such an entity exists. Otherwise, a staff individual with broad experience in Hazards Analysis and System Safety should prepare the necessary background material. In the event disagreement on the review terms of reference cannot be resolved within the panel, the chairman of the panel should submit the opposing viewpoints for Hqs reviews to the Director, OPTA, whose decision will be final. For field reviews, the differences should be resolved by the appointing official.

REVIEW OF SAFETY ANALYSIS REPORTS

Purpose. Reviews of Safety Analysis Reports serve two purposes. They provide assurance that all significant hazards have been identified, and that hazard controls are adequate to keep residual risks at an acceptable level.

Function. Safety Analysis Report review is a staff function providing a service to both the line organization which prepared the safety analysis in terms of feedback on adequacy of the safety analysis and to the executive responsible for approving the safety level of the facility.

Review Panels. Safety Analysis Report review panels should consist of persons not connected with the specific project but who are knowledgeable of environmental safety and health and cognizant of the energy conversion processes involved in the project.

The review panel, as called for in DOE 5481.1, must be comprised of individuals not in the same direct line of authority as those who prepared the hazards' analyses and resulting Safety Analyses Report. The members of the review panel should have sufficient expertise to critically evaluate the documentation, with special emphasis as to:

- Are the conclusions in the analysis valid? Are they based on studies of the proper scope and intensity?
- Were the proper issues identified and addressed in a satisfactory manner?

- Were valid standards or criteria used for the analyses? What other quantifiable or intangible consequences were measured and how?
- Are there other problems or conditions which still require further study?

ADMINISTRATIVE PROCEDURES

A preliminary meeting of the full panel should be held as early as practical after the members have been designated. At the initial meeting an agenda for accomplishing the review should be prepared including scheduling subsequent meetings. Also during this meeting, time limits for review, general format of documentation to be prepared and similar matters should be resolved. In test reviews conducted for OPTA it was found that the most efficient, and effective and economical reviews resulted from each member of the review panel reviewing the safety analysis separately and each preparing individual comments for group discussion at a subsequent meeting. In this manner it was found that reviews can frequently be accomplished with three meetings: one to establish review procedures and criteria; one to discuss the individual findings and establish a panel recommendation on safety acceptability; and, one to review the final report being submitted to the authorizing official. Where the Safety Analysis Report is inadequate, additional meetings must be held. In many instances involving a large scale project, sub-elements of the safety analyses may have to be reviewed over a considerable period of time. These same procedures would apply.

Time Limits. Time limits for a SARS review can only be established with reference to the safety analysis needs of a particular project. Some projects will require only a single analysis and review. Others, as indicated above, will consist of multiple, time-phased analyses each requiring a separate review.

The time allocated to each review effort must be minimized so that follow-up action by the organization preparing the safety analysis report, if needed, can be performed and results resubmitted to the Review Panel. In this way deficiencies can be corrected and additional information to perform the evaluation can be provided within the milestones scheduled. The following times are suggested as general guides for review efforts and are within the framework and intent of the SARS review schedule guidance contained in draft FE 5481.1:

1. High Risk - 15 working days
2. Moderate Risk - 10 working days
3. Low Risk - 5 working days

General Guidance for Reviews. Allowing broad latitude for professional judgment, review panels should include the following general topics in their consideration:

- a. Scope of Safety Analysis Report. The review should determine whether the level of safety analysis described in the report is consistent with the risk and nature of the project.
- b. Use of Modeling Techniques. The review should assess whether there has been over-reliance on the use of mathematical models including computer analysis. Where these methods have been used, the review should take into account how the results influenced risk assessments and were translated into safety features.
- c. Analysis of Risk Factors. The review should examine whether the analysis has presented for each identified hazard or accident risk, the following:
 1. Key assumptions and analyses inputs, including the criteria applied.
 2. Assessment of how the hazards could evolve into accidents or unsatisfactory conditions, and an identification of the design or other features that have been or will be needed to control or eliminate that potential. Interface of different sub-elements, as contained in such hazard analysis procedures as Failure Modes and Effects Analysis, need to be examined. Does the Analysis take into account downstream or upstream events arising from a subsystem hazard.
 3. Traceable verification that the identified hazard controls or alternative approaches have been implemented and meet requirements of DOE Order, Federal, State, and local and other codes, standards, and regulations.
 4. Consideration of all safety related features and requirements such as training of operators and maintainers, management systems, testing, checkout, storage transportation, maintenance, etc.
 5. Identification of all pending safety action items which would affect the residual risks.
 6. An easily understood rationale supporting the risk-level conclusions.

SAFETY ANALYSIS REPORTS

Energy conversion sites are complex. Not only does the site contain process equipment, but also material handling, pollution control, and site services equipment.

Equipment hazards are not the only hazards of concern. Work practices, worker skills, administrative procedures, maintenance procedures and other aspects of the entire energy conversion process can contribute to lack of safety. In some

instances deliberate excursions into limited or lack of control situations are made to contribute to process development. These risks must also be considered in conducting the Safety Analysis, and discussed in the Safety Analysis Report. In Safety Analysis the goal is to identify the hazards, define the controls and evaluate the effectiveness of these controls and a definition of the residual risks. Not all of the documentation associated with a detailed safety analysis need be presented in the Safety Analysis Report. The SAR, however, must present sufficient evidence that such documentation does exist.

- a. Hazard Identification. Identifying the hazards associated with an energy conversion process involves three separate considerations. These are:
 - Consideration of all items leaving or entering the physical site including each item of equipment.
 - All events and activities except for construction activities, which are the subject of other control requirements.
 - All hazards resulting from the energy conversion process, natural phenomena, normal operations, repair and other activities including decommissioning. In identifying hazards, a safety analysis cannot presume that hazards do not exist simply because of widespread experience in using the equipment or because it is normally well safeguarded. All hazards should be identified.
- b. Hazard Severity. Consequences of the hazard if an accident should occur need to be identified in order that requirements for control can be defined. In establishing the consequences, consideration must be given to the fact that a hazard may have more than one consequence. Injury, illness, property damage and environmental damage may result from a single hazard. Likewise, the circumstances of exposure to the hazard by personnel, property and environment on- and off-site must be considered.
- c. Hazard Controls.¹ A variety of strategies are available to provide control over hazards. These are:
 - Prevent creation of the hazard.
 - Reduce the amount of hazard brought into existence.
 - Prevent release of the hazard.
 - Modify the rate or spatial distribution of release of the hazard.
 - Separate, in time or space, the hazard from that to be protected.

- Separate the hazard by barrier from that to be protected.
- Modify basic characteristics of the hazard.
- Increase resistance to damage of that to be protected from the hazard.
- Counteract damage already initiated.

These principles resolve themselves into four basic categories of prevention. These are:

1. Elimination of the source of the hazard from the system or substitution of a less hazardous element
2. Engineering design of a control system
3. If the first two are not feasible, establish and enforce a management control system
4. If the hazard still remains, provide and enforce a personal protection program

REVIEW CRITERIA

The term "safety" is imprecise in meaning because it is multi-dimensional. It has both depth and scope. The depth aspect concerns "how safe is safe?" In this respect safeness can be said to be achieved when the risks remaining are proportional to those encountered by the general public in the course of everyday lifestyles.

The other dimension of safety, scope, relates to the question "safe from what"? The SARS review is concerned with the broad spectrum of hazards, injury hazards, illness hazards, environmental damage hazards, and equipment and property damage hazards. The objective of evaluating this aspect of safety during the SARS review is to assure that control of these hazards will exist over the life cycle of the facility, from acquisition through operation to decommissioning in such a way that risk is held as low as possible.

- a. General Review Criteria. Criteria for review to be applied to all facilities, processes and technologies include evaluation of the characteristics of the situation that can lead to harmful interactions with people, environment and property on- and off-site. Frequently, these result from the transfer of energy in such ways or amounts and at such a rapid rate that damage occurs. To assist in identifying these concerns which should be addressed in the SAR report, a list of energy related hazards, Appendix 1, is provided. Examples of general characteristics to be considered during the review include:

Operational time line
Energy sources and effects
 Meterological
 Geophysical
 Etc.
Effluent releases
Fire and explosion
Radiation levels
 Thermal
 Magnetic
 Etc.
Warning devices
Noise
Fire extinguishing provisions
Emergency procedures
Administrative procedures
 Employee selection
 Training
 Health screening
Abort provisions
Waste disposal
Start-up, repair, and maintenance
Control and instrumentation

- b. Specific Review Criteria. Each energy technology has specific safety concerns which should be considered. Appendix 2 lists safety concerns related to fossil energy technology. Appendix 3 depicts how specific safety concerns relate to specific technology development. Appendix 4 illustrates the relationship of these concerns to coal liquefaction. Obviously, the specific items will vary in the Safety Analysis Reports, due to the differences in technologies involved in the various FE projects. The several Appendices to the report are provided to illustrate the concerns which should be examined and identified in preparing the "Terms of Reference" to a particular review. The importance of having qualified process personnel on the review panel is illustrated by the coverage discussed in these Appendices.

RESIDUAL RISK ACCEPTANCE

Inherent in any safety program is the need to accept residual risks. These risks arise from both the lack of knowledge about new technology and the lack of certainty in controlling or eliminating hazards. Regardless of the procedures used some probability exists that an undesirable event will occur. This is the residual risk.

DOE has defined the objective criteria for safety from hazards as the level of risk normally encountered and accepted by the public in the course of everyday lifestyles. There have been a number of studies on the subject of voluntary versus involuntary risk acceptance by the general American public.

Among these are studies by the National Academy of Science⁸, and by various scientists.^{2,3} There is virtually unanimous agreement that the actual or estimated risk can never in fact be zero. As one authority points out, "It is customary to notice one event that kills 100 people rather than to notice 100 events that each kill one person."³ A proper risk assessment must give suitable attention and concern to the possible evidence of circumstances and event which can lead to either.

In order to place this risk level in perspective and provide a basis for measuring acceptability of risk, the following information is provided. It is based on a review of some of the previously cited references. The United States death rate from disease is approximately one death per year per hundred people. The death rate from natural hazards (earthquakes, tornadoes, flood, etc.) is about one death per year per one million people. While efforts are being made to reduce both of these, they can be considered as accepted risks by the majority of people. As a criteria for evaluating risk levels and residual risks acceptability, any risk of death or serious injury greater than the U.S. death rate from disease should be considered excessive. High risk would exist if this level is approached, moderate when risk levels are 10 to 100 times less than the U. S. death rate from disease, and low if the risk level approaches the level of the death rate from natural hazards. This suggested criteria is provided in the following table.

<u>Risk Level (DOE Categories)</u>	<u>Probability of Death or Serious Injury</u>	<u>Acceptability</u>
Excessive	$> 1 \times 10^{-2}$	Never
High	1×10^{-3} to 1×10^{-2}	Only in unique situations
Moderate	1×10^{-5} to 1×10^{-3}	Frequently
Low	1×10^{-6} to 1×10^{-5}	Usually
Negligible	$< 1 \times 10^{-6}$	Always

SAFETY ANALYSES DOCUMENTATION CONSIDERATIONS

No single format has been established within DOE for documenting a Safety Analysis. Standards and specifications for structure, content, and method of presentation of the report are lacking. Since omissions of pertinent information have been observed in previously submitted safety analyses, a table of contents is provided in Appendix 5 to aid in determining if all needed information has been included.

APPENDIX 1

TYPICAL ENERGY AND HAZARD SOURCES

<u>Energy Source Group</u>	<u>Subgroup</u>	<u>Examples</u>
1. Potential	Electrical	Battery banks, generators, service outlets, wiring, equipment, transformers
	Nuclear	Reactors, subcritical facilities, laboratories, hot cells, casks, vaults
	Gravitational	Lifts, cranes, hoists, scaffolds, ladders, elevators
	Pressure	Boilers, gas bottles, pressure vessels, coiled springs
2. Kinetic	Linear	Vehicles, forklifts, presses, crane loads
	Rotational	Centrifuges, motors, pumps, fans, gears
3. Chemical/ Biological	Corrosive	Acids, caustics, chemicals, solutions
	Explosive	Dynamite, explosives, powdered metals, hydrogen, acetylene, other gases, volatile liquids, nitrates, peroxides
	Toxic/ Pathogenic	Acetone, fluorides, carbon monoxide, lead, ammonia, asbestos, dusts, and particulates, pesticides, herbicides, insecticides, bacteria, beryllium, chlorine, heavy metals
	Flammable	Paper, rags, gasoline, oil, paint thinner, solvents, paint
4. Thermal		Convection, heaters, equipment, furnaces, cryogenics
5. Radiant	Electromagnetic/ Particulate	Radioactive: neutrons, gamma rays, x-rays, alpha particles, beta particles, radiography and x-ray equipment; thermal radiation: furnaces, equipment, solar; ultraviolet radiation; laser radiation; acoustical radiation: equipment noise, ultrasonic cleaners

APPENDIX 2

SPECIFIC ENVIRONMENTAL, HEALTH AND SAFETY CONSIDERATIONS FOR SAFETY ANALYSIS REVIEWS

Air supply during equipment cleaning, repair and maintenance

Waste liquid disposal procedures

Physical barriers against noise exposure

Physical barriers against thermal exposure

Disposal of contaminated wastes

Protection against hazardous leaks

Protection against explosions

Fire suppression systems

Fire particulates control

Effluent treatment procedures

Process materials contamination protection

Solid waste disposal procedures

Gaseous emissions control

Control of volatiles

Control of toxic substances

APPENDIX 3

	Oil Shale-In Sites Surface	Oil Shale-In Sites	Indirect Liquefaction	Direct Liquefaction	Enhanced Oil Recovery Heavy Oils	Enhanced Oil Recovery Steam Flooding	Enhanced Oil Recovery Micellar, Polymer & Alkali	Surface Gasification	Tight Gas Formation	Devonian Shale-Gas Recovery	Direct Coal Firing	Direct Coal Firing Advanced Scrubbers	Coal Oil Mixture	Enhanced Oil Recovery Light Oils
Dust Control	X										X			
Effluent	X													
Liquid Waste	X	X		X				X	X			X	X	
Toxic Residuals	X		X	X										X
Waste Disposal		X		X					X			X	X	
Fugitive Emissions		X												
Toxic Substances Control		X	X					X	X	X		X	X	
Carcinogenic By- Product		X	X	X		X		X				X	X	
Site Access After Phase Out		X												
Solid Waste Control		X	X	X				X		X		X	X	
Fire and Explosives					X	X	X				X	X	X	
Asphyxiation					X									
Temperature					X	X								
Pressure					X	X								
Noise					X	X			X					
Transport					X		X	X		X		X	X	X
Storage					X		X	X		X		X	X	X
Emissions						X	X		X	X	X			X
Materials Handling							X	X		X		X	X	X
Leaks and Spills							X							
Corrosion/Erosion							X							
Hazardous Substance Exposure								X						
Fracture Fluids Control									X					

APPENDIX 4

COAL LIQUEFACTION ENVIRONMENTAL, HEALTH AND SAFETY IMPACT AND HAZARD CONTROL REQUIREMENTS in Coal Liquefaction

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APPENDIX 5

SUGGESTED SAFETY ANALYSIS DOCUMENTATION CONTENTS

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Summary

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Prevention
Mitigation

Environmental Protection Systems
Waste Handling, Storage, and Disposal Systems

Safety Analysis

Safety Analysis Methodology

Hazards Analysis
Accident Analysis
Risk Assessment/Measurement

Normal and Off-Normal Operation

SUGGESTED SAFETY ANALYSIS DOCUMENTATION (Con't)

Potential Hazard and Energy Sources

Natural Phenomena

- Design Basis Earthquake
- Design Basis Tornadoes
- Design Basis High Winds
- Design Basis Floods
- Other Natural Phenomena

Operational Hazards

- High Voltage
- Flammable Explosive Gases
- Moving Equipment
- Toxic Materials
- Compressed Gases
- Other Potential Hazards

Extrinsic Hazards

Accidents

Natural Phenomena-Related Accidents

- Earthquakes
- Tornadoes
- High Winds
- Floods
- Other Natural Phenomena

- Operational Accidents
- Extrinsic Accidents

Disruptive Acts

- Frequency and Magnitude
- Disruptive Act Scenarios

Conduct of Operations

- Organization
- Personnel Training
- Quality Assurance Programs
- Operational Procedures and Limitations
- HS&E Management
- Waste Management
- Decommissioning Plan
- Security Systems
- Planning for Emergencies (TBD)

Operational Limitations (TBD)

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