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Special Projects Division Quarterly Report of Progress for the Period 1 January Through 31 March, 1980

Special Projects Division

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SPECIAL PROJECTS DIVISION
QUARTERLY REPORT OF PROGRESS
FOR THE PERIOD
1 JANUARY THROUGH 31 MARCH 1980

Special Projects Division 1418
Sandia National Laboratories
Albuquerque, NM 87185

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CONTENTS

	<u>Page</u>
HIGHLIGHTS	7
INTRODUCTION	9
QUARTERLY PROGRESS FROM 1 JANUARY THROUGH 31 MARCH 1980	11
Systems Studies and Planning	11
Technical Systems Studies and Planning	11
Methods Development	11
Information System Design	16
Management Planning and Systems Studies	20
Implementation Activities	22
Supporting Investigations	23
Training and Consultation	23
Publications and Presentations	24

ILLUSTRATIONS

Figure

1	Illustration of Environmental Components	12
2	Some Basic Elements of Safety Assessment	13
3	Populations at Risk	14
4	An Illustration of a Control Matrix	15
5	Control Use Information Form (Printout)	18

HIGHLIGHTS

Draft versions of 5 of about 18 planned "guidelines" documents, designed to facilitate implementation of Environment, Safety, and Health (ES&H) Assurance programs, were completed this quarter. These include: "A Model Corporate ES&H Assurance Program Plan," "A Model Line Organization ES&H Assurance Program Plan," "Guidelines for Safety Meetings," "Internal ES&H Audit and Appraisal Guidelines," and "Line Organization Safety Committee Guidelines." These documents are in various stages of review and revision.

The conceptual design of the ES&H Assurance Program Information System was essentially completed this quarter. Some of the subtasks completed were (1) the development of a method for classifying risk factors associated with a given hazard, (2) the development of a method of classifying known controls for addressing risk factors, and (3) the initial design of the computer output format for portraying the risk factors and their controls for a given hazard. Methodology has been tested in each of these areas, using data generated from Safe Operating Procedures of the Quality Assurance--Engineering and Evaluation Department and from equipment lists from other organizations.

Exposure of the ES&H community to Sandia's Assurance program concepts has continued. In particular, Special Projects Division personnel were asked to return to Western Electric Headquarters for a 3-day working session that would help the Industrial and Environmental Engineering Planning Staff to fully understand Sandia's approach so that they might adapt it to their needs and try it out somewhere within the Western Electric system.

INTRODUCTION

Activities of the Special Projects Division at Sandia National Laboratories (SNL) have as their goal the development of a program for efficiently assuring that ES&H activities within the Department of Energy (DOE) are "adequate." This development effort encompasses a planning phase, based on past "assurance" experience; a testing phase to determine, as far as practicable, the cost-effectivity of plans; an implementation phase to develop implementing guidelines and procedures; and a training phase to assist in successful implementation.

A complete description of past activities is given in the following reports:

1. Special Projects Division Quarterly Report of Progress for the Periods 1 October through 31 December 1978 and 1 January through 31 March 1979, SAND79-0796, April 1979.
2. Special Projects Division Quarterly Report of Progress for the Period 1 April through 30 June 1979, SAND79-1486, August 1979.
3. Special Projects Division Quarterly Report of Progress for the Period 1 July through 30 September 1979, SAND79-1967, October 1979.
4. Special Projects Division Quarterly Report of Progress for the Period 1 October through 31 December 1979, SAND80-0068, January 1980.

These reports, and the references therein, are available through the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

QUARTERLY PROGRESS FROM 1 JANUARY THROUGH 31 MARCH 1980

Systems Studies and Planning

Technical Systems Studies and Planning

Methods Development -- Activities in this area are designed to provide guidance for performing those technical functions determined to be necessary in an ES&H assurance program, based on past planning efforts (see reports listed on page 9, and attendant publications listed therein).

Preliminary studies were completed and draft documents prepared this quarter addressing methods for performing the following technical functions, whose needs were previously identified:

- The utilization of Quality Assurance programs in support of ES&H assurance and
- Safety assessment functions.

These documents are in various stages of review and revision.

Other technical methods documents, still in the planning stage, will address:

- ES&H staff audit/appraisal programs,
- Hazard identification,
- Risk factor identification,
- Inspection and monitoring activities, and
- Line organization and ES&H staff review activities.

As an example of progress this quarter, an overview of safety assessment functions was prepared in preliminary form. Per past planning efforts (see reports, p 9), a hazard is viewed as a thing having the potential for causing injury to, or illness in, humans, or damage to the environment. In this context, the "environment" is, in turn, viewed as having numerous logical or legal components--as shown in Figure 1. Some examples of the types of concern inherent in each component are shown. Most of these, from the DOE perspective, stem from legal requirements.

Figure 1. Illustration of Environmental Components

From the point of view of safety assessment efforts, hazards are further divided into two fundamental classes: those which are routinely encountered and accepted by the general public (termed "routine") and others (which are termed "significant"). The ES&H Assurance Program Standard, published in SAND79-1536 (and elsewhere -- see reports, p. 9), requires that safety assessments be performed on "significant" hazards, and this definition provides a comfortable interpretation of "significant" that is consistent with the requirements of DOE Order 5481.1, "DOE Safety Analysis and Review System."

For significant hazards, safety assessment begins with the recognition that hazards present only a potential for causing human injury or illness or environmental damage, and that certain events must occur in order that this potential be realized. It is then logical that, if the events are avoided, injury, illness, and damage are also. Thus, in the scheme being developed, the emphasis in safety assessment is placed on identifying the events which can lead to injury, illness, or damage, and on defining controls over them which will lead to "acceptable" consequences.

More precisely, the term "consequences" is used in the traditional way to denote the nature and scope (or "severity" and "exposure") of the potential injury, illness, or damage that may be associated with a given significant hazard. The different events which are involved in realizing these consequences are identified. The likelihood of the events is viewed as depending upon risk factors--and it is over these that control

is exercised. Event trees or fault trees are offered as reasonable techniques for the derivation of risk factors--which then become the "end" events in the tree--with the caveat that they must include non-traditional types of risk factors dealing with human performance, administrative system failure, and operational settings as specified in past planning efforts. Figure 2 gives a brief illustration of this approach in terms of a pressure system (the hazard), its generic potential consequences of concern (in this case, injury to employees), the generic events involved in the realization of the consequences (system rupture and exposure), some of the risk factors upon which the likelihood of these generic events depends (hardware strength and reliability, barrier integrity, etc.) and some of the controls that may be exercised over those risk factors (system and material tests, design reviews, access control, procedures, etc.). Note that, in this scheme, the question of exposure is treated as an event--the level of exposure depending upon the control exercised over the presence of personnel. In a similar manner, severity can, in fact, be controlled also.

Figure 2. Some Basic Elements of Safety Assessment

The types of control that may be exercised over risk factors vary appreciably, ranging from hardware design controls to procedural operational controls. The types elected should be dependent upon the potential consequences. For example, the approach to safety assessment being developed suggests that humans be treated in the three categories shown in Figure 3. In general, as one moves from left to right in Figure 3, greater or more assured control must be exercised, although other variables enter into such decisions. The "acceptability" of controls should be determined, in part, by their acceptability to the population "at risk."

Figure 3. Populations at Risk

Finally, as alluded to above, controls may be viewed as being one of four types: design limiting, nonintegral protective equipment, warning devices, or procedural. Depending upon circumstances, it might be anticipated that the "reliability" of the controls themselves would decrease in the order listed.

Since controls can be exercised over event probabilities, including expected exposure and level of severity, a "Control Matrix" can be constructed for any collection of risk factors deemed important for a given event or collection of events. Such a matrix is illustrated in Figure 4, where there may be some interdependence among categories. For example, procedures might dictate the use of safety equipment. Because of this, entries in such a matrix can convey even further information by specifying not only the number of controls of each type, but whether, for example, any given control is

		CATEGORY OF CONTROL			
		Limiting Design	Nonintegral Protective Equipment	Warning Devices	Procedural
CONTROL OVER	Likelihood of Event Occurrence				
	Expected Exposure	Numbers and "Types" of Controls (see text)			
	Level of Severity				

Figure 4. An Illustration of a Control Matrix

- Additive -- that is, genuinely contributes to total control above and beyond other listed controls (decreases the probability of an event, the expected exposure or level of severity),
- A "Backup" -- does not change the probability of an event, the expected exposure or level of severity in the presence of other listed controls,
- Effectivity
 - Dependent -- depends upon the existence of another control for its effectivity, and
- Failure
 - Dependent -- fails automatically if another, listed, control fails.

These categories are used to give a "rough" idea of what may be possible. Other types of information might include whether or not controls are over "technical, human, administrative, or operational risk factors" (see reports, p 9) and/or include information about the control reliability in terms of the frequency of use, degree of human involvement, amount of tedium, etc. These possibilities are being explored. With information of this sort arranged in the convenient matrix form of Figure 4, it is felt that it will be easier to define criteria for judging the "adequacy" (see Report 1., p 9) of the collection of controls

exercised over an undesirable event and to do so in ways that do not exclusively rely on "residual risk"--which is believed to be an unreliable measure of control "adequacy" and "acceptability" at the present time.

Information System Design -- The conceptual design of the information system for the ES&H Assurance Program was nearly completed this quarter. Next quarter will see the initiation of a field test of the information system and near completion of the computer programs for processing ES&H Assurance data in accordance with the conceptual design, which is based on past planning efforts and specific computer-oriented development efforts described below.

As indicated previously (Report 4., p 9), the information system has four functions. These are to process the data needed to

1. Prepare, review, evaluate, and update ES&H plans,
2. Generate checklists for conducting audits of the degree of compliance with ES&H plans,
3. Portray the results of the audits and initiate follow-up actions, and
4. Measure the performance/status of each organizational unit in terms of the degree of and changes in ES&H assurance attained.

The following tasks have been initiated and/or completed during the past quarter as a part of developing the conceptual design for each of the information system functions.

- Development of a method for classifying the risk factors associated with a given hazard -- This classification method is needed to capture all of the known information ("lessons learned" from previous experience with the hazard) about the risk factors associated with the hazard.
- Development of a method for classifying the known controls for addressing each of the risk factors identified for a given hazard -- This method is needed to capture, in computerized form, the known information about controls applicable to each risk factor identified for a given hazard. The classification of controls is also used to generate the audit checklists for conducting audits of compliance with ES&H plans (Function 2, above).

- Testing of the methodology for classifying risk factors and controls by type of hazard -- This testing has been conducted using a selection of hazards at SNL. Review and classification of existing Safe Operating Procedures and occupational and environmental safety and health standards related to these test hazards has been undertaken using the risk factor and control classification methodologies above.
- Initial design of the formats for the computer-generated output portraying the known risk factors and their associated controls for a given hazard -- An example of these outputs is shown in Figure 5. Outputs of this sort will be used to aid in generating those portions of ES&H plans that relate to specific hazards (Function 1). The outputs will provide the plan originator with the ability to note all previously identified risk factors and their related controls for the hazards in the organization. The outputs will also enable the plan originator to indicate which risk factors are applicable to the hazard being assessed and which controls are to be used to address these risk factors.

These outputs will also offer to the reviewer of the plan a systematic method for determining whether the plan originator has explicitly considered all risk factors and controls in developing his plan. The format is designed to allow additions of new risk factors and controls by the plan originator and the plan reviewer. Input from the plan originator on the controls that are to be implemented, after appropriate review, will be used to automatically generate the audit checklists for reviewing compliance with the plan (Function 2).

- Initial method for qualitatively classifying the controls used to address a given event (Function 1) -- This method is based on requiring separate evaluations of the degree to which controls address the expected exposure, the level of severity, and the likelihood of occurrence from and of events associated with a given hazard, and on ranking controls on a scale similar to that shown in Figure 4 in the subsection on Methods Development. Much of the work described in that subsection has been undertaken in order to effectively computerize ES&H Assurance Program data. The system will permit differentiation between risk

CONTROL USE INFORMATION FORM (PRINTOUT)
(EXAMPLE)

For Project/Activity: High Pressure Facility P | A | 0 | 0 | 0 | 1
 For Event Sequence: Overpressure/Rupture/Shrapnel, Whipping Lines, Gas Jet/Exposure E | S | | | |
 For Event/Consequence: Overpressure/Personnel Injury E | 0 | 0 | 0 | 8

Pg. ____ of ____

CONTROL TYPE	CODE NO.		CONTROL PRECEDENCE		REFERENCE GUIDES ON CONTROL SELECTION	IS CONTROL TO BE USED IN THIS PROJECT Yes/No Rationale, if "No"
	Type	No.	Rank	Type		
Pressure vessel designed to ASME specifications	CT	0001	1	Design	Gd Gd.1, p 2	
Pressure vessel designed with a safety factor of 4	CT	0002	1	Design	" "	
Pressure switch shuts off pump at operating pressure	CT	0003	1	Design	" "	
Rupture disk set to burst at MWP	CT	0004	2	Safety device	" "	
Rupture disk in low pressure system set to burst at 3000 PSI	CT	0005	2	Safety device	" "	
Pump stopped by operator at desired pressure level	CT	0006	4	Procedure	" "	
Pressure switch is set to required pressure for test underway	CT	0007	4	Procedure	" "	
Minimum of two qualified operators must be present during any operation	CT	0008	4	Procedure	" "	
Console barricade	CT	0009	5	Minimize damage	" "	
Test cell barricade	CT	0010	5	Minimize damage	" "	

Figure 5. Control Use Information Form (Printout)

factors associated with an event that directly affect the realization of undesirable consequences and those that can be assumed to necessarily follow once the precipitating risk factors have occurred. The controls addressing precipitating events are clearly more critical than those addressing subsequent events.

- Preliminary development of a methodology to identify interactive effects of two or more hazards (Functions 1 and 3) -- The goal of this methodology is to computerize a method for alerting ES&H planners to the incompatibilities between two existing plans, between an existing plan and one that is being developed, and between an existing plan that is being changed and other existing plans. The data elements identified as needed for this "automatic" alert to the incompatibilities between systems are covered in the space management computer program being developed. This program covers the location, type, level, and range of the energies involved for each hazard and the exposures (to people, environmental systems, and property) that are within the range of the hazard's energies.
- Development of a computer-oriented change control methodology (Function 3) -- This refers to the methodology for controlling changes vis-a-vis ES&H plans. The data elements for reporting changes and the scale for assessing the acceptability of changes have been developed in draft form.
- Development of a draft user's manual for preparing ES&H plans for a given hazard has been nearly completed (Function 1) -- This guideline instructs the plan originator on the structure of data inputs through ES&H plans and covers the identification of risk factors and controls, assessment of risk, and evaluation of the subsequent ES&H plan and its individual controls. A second guideline for plan reviewers will cover such topics as the evaluation of incompatibilities and changes in ES&H plans.
- Initial evaluation of the data processing needs to implement the Audit/Appraisal Guidelines (Function 2) -- This has included identifying the types of data and records of evidence needed to process information for each of the audit elements included in SAND79-1812, Audit/Appraisal Guidelines for Organizational ES&H Assurance Programs, November 1979 (see Reports 2 and 3, p 9). A

glossary of audit terms and identification of the interaction between audit elements has also been started.

Management Planning and Systems Studies

Progress was made this quarter in the development of methods for the performance of the administrative functions needed in an ES&H assurance program. The two drafts noted in the last quarter are part of this effort:

- Corporate ES&H Assurance Program Plan (a model of an institutional ES&H program) and
- Model Line Organization ES&H Assurance Plan.

Draft versions of the following documents were prepared during this quarter:

- Guidelines for Line Organization Safety Meetings and
- Line Organization Safety Committee Guidelines.

Other methods, still in the planning stage, include the following:

- A Model Corporate Emergency Response Program,
- Model Emergency Response Programs for Line Organizations,
- Guidelines for Record Keeping and Reporting, and
- A Corporate ES&H Assurance Training Program.

To illustrate the administrative methods, as they exist in draft form, the "Guidelines for Line Organization Safety Meetings" may be used. This document discusses safety meetings at the line organization, or operational, level and is based (as are all the methods) on "An Environment, Safety, and Health Assurance Program Standard" (see SAND79-1536, referenced earlier). The document acknowledges that the traditional function of safety meetings--the development of safety awareness--is an important function but argues that this might best be accomplished if the meetings (1) provide a vehicle for active personnel participation in the organization's ES&H program, (2) aid in the development of controls for "routine" hazards that are acceptable to those "at risk," and (3) provide personnel/management interaction on ES&H matters.

In order to improve personnel participation in safety meetings, the approach being developed recommends the use of forms on which personnel may submit reports (on incidents in which they have been involved or on

hazardous conditions they have observed) for discussion in the meetings. It is stressed that personnel participation is the cornerstone of a worthwhile safety meeting program, and it is recommended that there be positive and substantial recognition of participation. Much of the material used has been adapted from the human factors oriented "Safety Prone Program" developed by Dr. Alan Swain of SNL.

The approach recommends that the safety meeting agenda should be rather flexible in order to provide opportunity for personnel participation and to promote the informality which encourages such participation. However, inclusion of the necessary topics requires some minimal amount of agenda planning. The agenda items outlined below should always be included (when applicable).

A. Reporting and Discussion of Inspection and Audit Results

Every safety meeting should include the presentation of inspection and audit results. In fact, scheduling safety meetings after inspections or audits is desirable. The majority of the inspection or audit results reported should be those produced by organization personnel, but when external audits have been performed, their results should also be discussed in the meetings.

Reports should present both positive and negative findings. Sufficient time should be allocated for each report to allow a discussion of the results and to allow the development of a consensus concerning actions that have been or should be taken to address the negative findings.

B. Reporting and Discussion of Accidents/Incidents/Near Misses

This agenda item is similar to that for inspection and audit reports and involved personnel are encouraged to present them. Again, there should be a complete discussion and an attempt to develop a consensus concerning actions that have been or should be taken.

Accidents, incidents, and near misses may be reported on the Accident Factor Report Form or the Accident Prone Situation Report Form, which were developed for the Safety Prone Program devised by Dr. Swain.

C. Reporting and Discussion of Employee Inputs

The importance of personnel participation in safety meetings and, indeed, in the total ES&H program, cannot be overstressed.

The employee is the individual closest to the work situation and thus may be most familiar with the hazards involved in his task. In addition, the employee often exercises direct control over risk and is, in any event, one of those presumably "at risk." Therefore, it is believed that employee inputs and understanding are the cornerstones of a successful ES&H program.

D. Discussion of ES&H Program and Safety Procedures

The agenda for a safety meeting should always provide at least the opportunity for comments and discussion on the existing program and the procedures in use. Also, at least once every two years, the safety meeting should include a systematic review of the total program.

E. Presentations

Films and topical reports have been a standard part of safety meetings for many years. Although the guidelines being developed have stressed making the safety meeting a vehicle for systematic discussion of the organization's ES&H program, presentations, because of their educational value, are not neglected. They are, however, used only as supplementary material, and relevance to the business of the organization is stressed.

F. Summarization of Consensus and Recommendations

The final agenda item for each safety meeting should be a review or summarization of what has been discussed in the meeting. Emphasis is placed on restating agreements or recommendations reached during the meeting in order to be certain that there is an actual consensus. The ES&H Program Standard (referenced earlier) implies that these should be forwarded to management for formal action.

Implementation Activities

Activities directed toward the implementation of the ES&H assurance program have continued to focus on publicizing the approach and its potential benefits. There are dual objectives in this effort: to identify possible obstacles to implementation and to identify organizations that might have an interest in adopting this approach to management of their ES&H programs.

As previously reported (see Report 4, p 9), a great deal of effort was expended last quarter in developing a comprehensive briefing describing the nature of the approach, how it was developed and tested for costs and benefits, how it might be implemented, and the societal benefits that might accrue from its widespread adoption. During this past quarter, the briefing has been given several times, most notably in a 2-1/2-day working session with the Industrial and Environmental Planning Staff of Western Electric Corporation. This session was intended as a total learning session and may form the basis for future training sessions. This presentation is being documented to provide a coherent overview of our total program development/test efforts.

Supporting Investigations

Only limited activities in this area were conducted this quarter. Tests of the approach are being planned, however, as indicated last quarter. Many of the activities described above are necessary precursors to full tests of the approach which, however, will be conducted. They will extend through or possibly beyond this fiscal year and involve some tests within Sandia's Quality Assurance--Engineering and Evaluation Department. During the past quarter, several approaches to testing the information system have been devised. Selection of a test approach will depend upon the mode used to test the entire system. Limited testing of the cost-effectivity of the audit/appraisal guidelines has been planned within SNL. This test will use a restricted set of audit categories in assessing safety of a large field test this next quarter.

Training and Consultation

No formal training activity was undertaken this quarter. However, a 3-day human factors seminar specifically addressing nuclear activities was prepared by Dr. Alan Swain.

The seminar is divided into three parts: (1) A description of the factors that shape human performance in large man-machine systems such as nuclear power plants. These factors can result in reliable or unreliable human performance. They include the design of equipment and written procedures, the type of work operations and the amount of work

to be performed, training and provisions for on-site practice of responses to abnormal conditions, and so on. Human reliability can be materially improved by use of standard human factors techniques and designs. Examples of good and poor designs are given. (2) A description (including examples) of Man-Machines Systems Analysis (MMSA), the basic analytical tool for identifying potential human error problems and their causes. The MMSA includes the THERP human reliability analysis technique developed by Dr. Swain and used in WASH-1400. (3) An illustration of descriptive and quantitative modeling of human performance in large systems, using nuclear power plant tasks as examples. For each type of human task (in the control room, calibration or maintenance activity, inspection or monitoring procedure, etc.) the human performance models plot the estimated probabilities of human errors as a function of time. Variations in these plots result from different designs of equipment and written procedures, type of work operations, stress levels, individual differences, and so on. The quantitative representation of each model is a probability distribution. The implications of these distributions on the availability of safety systems are described and sample calculations presented. The models are speculative and represent a first approximation, but they have been derived on the basis of making psychological sense and of being in agreement with studies of human performance.

The 3-day seminar is based on Dr. Swain's experiences in nuclear reactors since 1968, including his role in WASH-1400, his follow-up studies of human error problems in nuclear power plants, including Three-Mile Island, and his development of human performance models in the Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, a document being prepared under contract to NRC.

Little consulting activity not mentioned earlier in this report was conducted this quarter.

Publications and Presentations

Publications and presentations include draft guidelines and the presentations of the comprehensive overview mentioned in the text of this report.

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