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CHANGE CONTROL AND ANALYSIS

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Prepared by

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The author wishes to express acknowledgment of the work of W. G. Johnson, which the author used very freely in the preparation of this text.[1,2] The author would encourage the reader to seek additional information on change from W. G. Johnson's Book[1], "MORT - Safety Assurance Systems." Many individuals within the Department of Energy and private industry have reviewed this document. They are acknowledged as significant contributors to the completeness of this document.

FOREWORD

The purpose of this document is to sensitize the user to the need for change control in on-going systems and the institution of safety-related counter-changes. It also emphasizes the need for after-the-fact analyses of changes and differences as potential causal factors of accidents and incidents. It should provide managers, supervisors, and safety specialists with concepts, information, and techniques for use in the control and analysis of unwanted change.

This document contains various change analysis worksheets to aid the user in the initial steps of change analysis. These worksheets are not intended as the panacea, but only as examples which might inspire the reader to do some creative thinking which will produce the needed job-related change control methods.

CONTENTS

FIGURES

I. INTRODUCTION

A philosopher once said, "Nothing remains the same." This adage alone should make one sensitive to change and difference, if for no other reason than today man and machine are another day older. Change can be thought of as stress on a system which was previously in a state of dynamic equilibrium. Change can also be viewed as anything which disturbs the planned or normal functioning of a system. History bears out the fact that there is a relationship between change and increased risk. It has been demonstrated that for any functional system which has been operating satisfactorily (i.e., up to some standard), when problems do arise, changes and differences associated with personnel, plant and hardware, or procedures and managerial controls have proven to be actual causal factors in the creation of these problems. Changes also have an indirect relationship with impending danger. For example, the jungle man has an acute awareness of his surroundings, a sense that remains dormant in most of us. This sensitivity warns him not only of direct danger, but of changes and differences in the patterns of jungle life, such as the eating habits of animals and the singing of birds, which could be preludes to impending danger. Not only in primitive societies, but in the modern industrial settings as well, change control and analysis should become essential elements in hazard identification and risk management.

II. THE CHANGE ANALYSIS PROCESS

Change analysis techniques were developed at the Rand Corporation, and improved by two former Rand employees, Charles H. Kepner and Benjamin B. Tregoe. Their book[6], "The Rational Manager" is a valuable resource aid in applying the techniques. Change analysis is a systematic approach to problem solving which can aid the manager in decision making, the appraiser in evaluating system functioning, and the accident investigator in identifying accident causes. The concept of change analysis allows the system analyst the latitude of determining whether (a) changes are needed in a stable operating system, or (b) if operational changes require safety-related counterchanges.

The first observation we can make is that our perception as to the time span when change becomes necessary has shrunk considerably. In ancient Egypt, things were done exactly the same way for entire dynasties, lasting millenia. In the Middle Ages, things were done the same way for centuries. In this century, change has taken place in terms of generations, i.e., 15 to 25 years. Now, however, our world is changing so fast that even things that are only five years old require change. Let us examine then the effects of change versus time. Figure 1 shows a rather pessimistic view of the exponential effects of changes over time as contrasted with the slow growth of safety-related counterchanges.[1]

Many examples can be found of systems where the commonly used indicators and guidelines (accident/injury rates, the absence of bad accidents, etc.) give indication of an acceptable program, however, the application of quite simple risk projection techniques reveals a high probability for a severe accident. This could also be done by simply comparing the same overall system with itself as it existed earlier. The number of changes which have occurred with no provision made for analyzing their consequences would probably amaze the evaluator.

EFFECTS OF CHANGE vs. TIME

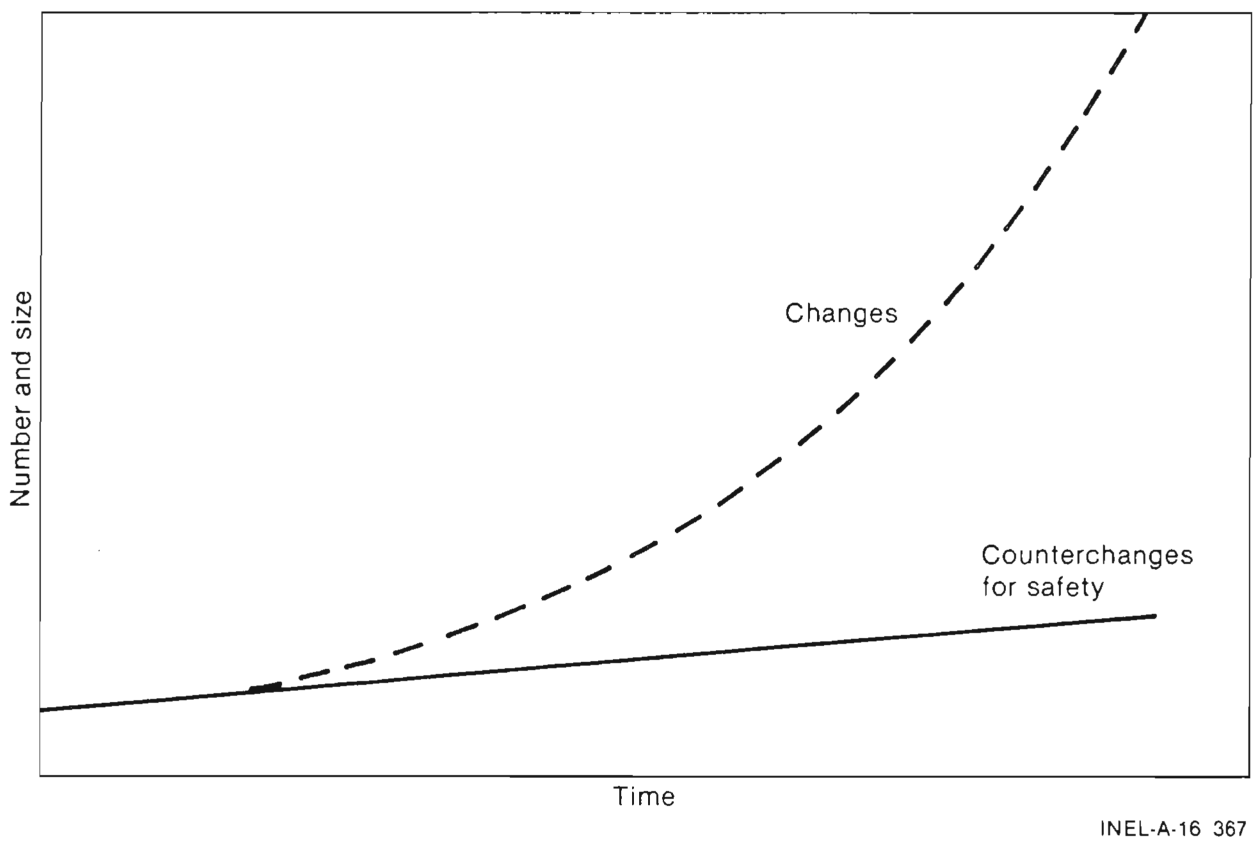

Figure 1. The exponential effects of change over time are contrasted with the slow growth of safety counterchanges.

The need for safety-related counterchanges is linked to the simple fact that any "real life" operational system is constantly experiencing changes in personnel, procedure systems, and equipment. Unfortunately, when such changes are made, many times the effect on the entire system is not evaluated. These oversights or omissions can, and many times will, lead to accidents or incidents.

Change-based analysis techniques are used in all walks of life from the auto mechanic to the medical doctor to give aid in the following areas:

- Trouble Shooting - Knowing what additional facts are needed. Very often, the relevant facts are quickly available if their need is pinpointed, and a change-based question format (i.e., what has changed?, or what is different?) is an efficient way to search for additional information.

- Finding Obscure Cause - At the initial stages of problem solving, who knows what the causal factors might be? Therefore, it is important that all changes and differences are identified whether they appear to make any difference or not. Change and difference analysis quickly pierces the obscurity and helps prevent wasteful and ineffective action on false causes. The method helps to reveal the causal factors which are not obvious.

- Analysis of "Keystone Kop"-Type Activity - If change is not identified and controlled, it may soon compound and produce the Keystone Kop-type activity. An example of Keystone Kop activity is where you have knowledgeable and competent personnel who nevertheless tend to fall apart under abnormal or emergency conditions. The chances are quite high that they have been overwhelmed with change. Likewise, the initiation of uncontrolled change can compound or cascade to produce the same effect. For example, a farmer operated a medium size dairy farm. Under normal operation, the cows would file into the barn and find their customary stall each morning and night. We could always tell when he had a new cow in the barn, for as soon as the new cow found a stall that seemed to fit she took it, leaving the cow which usually occupied that stall without a place to go. As innocuous as the change of introducing a new cow into the system might seem, within a short period of time, the barn was in a state of complete chaos with cows not knowing where they should be. He found it easier if he would hold the new cows until last, thus controlling the unwanted aspects of change. Within a short period of time, the new cows learned their position in the system and operation returned to normal.

- Quick Entry Into Problem Solving - When time is short for problem analysis and the need for remedial action is urgent, change analysis techniques provide a systematic approach for quick entry into problem solving with very high credibility.

- Avoiding Invalid Use of Old Solutions for New Problems - Some managers have canned solutions for problems possessing certain characteristics. When a similar problem occurs, they apply the solution that worked the last time, only to find themselves treating symptoms of problems, rather than diagnosing and curing the cause. Case in point: A patient went to the doctor and the doctor said, "What did you have the last time you had these symptoms?" The patient told him and the doctor replied, "Well it looks like you have it again." The application of change analysis can help avoid the improper use of old solutions for new problems. For example, if the doctor had been treating the patient for migraine headaches in the past, and today the patient again has a headache, change analysis might assist the doctor to detect that today the patient is suffering from a brain tumor instead of a migraine headache.

Change Analysis should be used by the analyst in two ways:

1. Operational Change Control - As a method of analyzing change in a system "before-the-fact" in the same manner, one would develop Analytical Trees. However, remember you are analyzing known or suspected changes in a system, subsystem, or procedure to evaluate its effect on the process, along with recommending possible safety-related counter changes.

2. Accident/Incident Change and Difference Analysis - As a method of pinpointing changes and differences that may have had potential in causing an accident or near miss. A change analysis used in this manner would be an "after-the-fact" analysis and would be used to supplement the causal factor analysis which is used in Accident/Incident investigation.

These two techniques are the topics of the next two sections and should indicate what effects the change had or will have on the immediate components of the system. One should remember that all parts of a system are interrelated and a determination must be made as to its effects on other components and, subsequently, the entire system.

III. OPERATIONAL CHANGE CONTROL

Change analysis is an effective tool in searching out potential problems associated with proposed changes in stable operating systems. A formal change review system is essential in the control of this change, which would review proposed changes in personnel, plant and hardware, or procedures and managerial controls. Also necessary in operational change control is the need for supervisory detection of change, and the need to monitor for change. The role of the supervisors in change analysis and the management of changes can not be overemphasized. The supervisor who is aware of change analysis techniques can correct problem areas which are sometimes inadvertently built into a new facility or equipment modification. Change is essential in our modern technology but the management of these changes for safety is paramount.

Change Review System

Systems fraught with changes usually generate additional hazards. We need to be sensitive to the nature of "change." We need to be sensitive to changing situations -- transfers, new machines, new materials, new operations, modifications, shutdowns, startups, etc. Sensitivity to change and the possible need for an offsetting counterchange is a mark of excellence for a manager, supervisor, or safety professional. We need to explore training methods to sensitize supervisors to detect and react to significant changes. In systems theory, review and counterchange should follow every "significant" change. In complex systems, particular attention must be given to the compounding of change. For example, in one case investigated, a change made five years previously combined with a change made shortly before the accident to produce the undesired consequences. Another factor which must be considered is the introduction of gradual change (e.g., deterioration of equipment or growing laxity in administrative controls) as compared with the discontinuous change (e.g., a modified hardware configuration or presence of a new employee). At this point in time, it might be helpful to examine a case history which illustrates change and the sequencing of change:[2]

Base of Reference - A large chemical plant had operated uneventfully for years.

Change 1 - The plant was replaced by a larger, more efficient plant.

Change 2 - The first plant was decommissioned and partially disassembled.

Change 3 - The new plant did not produce as well as expected (at first).

Change 4 - Demand for the product grew more rapidly than expected.

Change 5 - Management decided to put the old plant back in production.

Can you see the problem beginning to form? Let us take a look at the rest of the scenario.

Change 6 - The necessary operating controls were reinstalled in the old plant to get it back in production as quickly as possible.

Error - No formal review for hazard analysis and/or operational readiness was performed.

Change 7 - Some redundant safety controls were not reactivated (lack of safety-related counterchanges to change).

Change 8 - The plant exploded, killing six men.

We seem justified in concluding that change-based analytic techniques are not being used for preventive, before-the-fact work to decrease both operating and safety problems. The needs seem to be:

A. Establish the significance of changes in causing trouble, beginning with top management statements and action. Then sensitize and train middle management. Then do the same for supervisors.

B. Establish a routine analytic format for efficient, effective analysis of changes -- a reviewable, visible method.

The potential problem worksheet Figure 2 can be initiated at the inception of a new project and expanded as the project develops. As the differences from the past are exposed, appropriate expertise can be brought to bear. Experience indicates this low-cost form of analysis is amazingly effective in drawing appropriate attention to the causes of future problems and will give visibility to changes and differences which would otherwise be overlooked.

If change is a cause of the trouble, why wait for trouble to do the necessary analysis?

H. B. Butcher, formerly of Reynolds Electrical & Engineering Company (REECO),[3] now with Williams-Fenix and Scisson has developed a change analysis method which is useful in controlling change. The work sheets for the method are contained in Appendix A.

Monitoring for Change

It seems apparent that most complex systems depart from plans and procedures to some degree. Therefore, the need exists to detect deviations (changes), initiate corrections (counterchanges), and in

Change-Based Potential Problem Analysis Worksheet

Specify Problem ____

Factors	Present	Prior Comparable	Differences, Distinctions	Affecting Changes	Counter Changes

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Figure 2. The change-based potential problem analysis worksheet shows a preventive counterchange column. Specify the changes in a project as compared with recent conditions or comparable projects.

general assure that goals are attained. Let us examine some of the elements necessary in monitoring for change:

A. Planned Change vs. Unplanned Change

1. Planned change should require a scaled hazard analysis process (HAP) review, and affirmative safety action.

2. Unplanned change must first be detected by monitoring. When detected, immediate preventive action should be taken when necessary, and a scaled HAP review should be triggered. Also, strong review requirements can help detect unplanned and unreviewed changes.

B. Actual Change vs. Potential or Possible Change

1. Actual change is detected by reports and observations.

2. Potential or possible change requires analysis.

C. Time Changes

A monitoring system should be able to identify the deterioration of a process over time, and the interaction with previous changes.

D. Organizational Changes

Shifts in unit responsibilities may leave interface gaps, particularly when the hazard analysis process is ill-defined. The monitoring system should help in detection of these types of problems.

E. Operational Change

Monitoring should help detect changes in procedures and processes which require safety review.

IV. ACCIDENT/INCIDENT CHANGE AND DIFFERENCE ANALYSIS

Experience has shown that one of the more important factors in producing accidents and incidents is change. Even in the absence of accident investigation experience, it is intuitively obvious that if tasks and jobs comparable to those involved in an accident have been conducted in the past without incident, changes and differences provide a logical focal point in accident investigation. Thus, one of the objectives in conducting accident investigations should be to establish accident-free reference bases and then systematically search out changes and differences relative to accident situations.

Superficial study of accidents/incidents based on mere guidelines may very often obscure cause and effect relationships. What may appear to be the cause of an accident could be, in fact, an effect produced by a less obvious change mechanism. Discussion of an actual case may illustrate the need to probe energetically for the primary cause.

> In a chemical factory, the number of workers hit by forklift trucks while crossing aisles increased suddenly and dramatically without any apparent cause. Whenever such a "lost time" accident report was filed, either pedestrian error or driver error was listed as the cause. Subsequently, common human factors engineering approaches likely to eliminate the problem were explored. The trucks were made more visible by painting them in conspicuous colors, and illumination in the aisles was improved. At some of the places of greatest accident frequency, automatic warning horns were installed which signaled whenever a vehicle approached. When none of these measures proved to be successful, investigators tried to discover why so many individuals were walking around the factory instead of remaining seated safely at their workplaces. Accident frequency was proportional to the number of

pedestrians present in the aisles at any given time. Brief periods of absenteeism from the workplace had suddenly increased dramatically, leading in turn to an increase in pedestrian traffic density.

The time of this change coincided with the introduction of a new tool. An electrical brush used to clean trays was replaced by a much less expensive but equally effective paint scraper that produced insults to the ulnar artery. This reduced blood supply to the ring and little fingers. The resulting numbness and tingling caused the individuals afflicted to lay down their tools occasionally and seek relief by exercising their hands. To avoid ensuing arguments with supervisors, workers were tempted to make use of every opportunity of brief absences from the job. Trips to the washroom, the toolroom, etc., became much more frequent, and this was the true cause of increased exposure of the factory population to the risk of traffic accidents. Thus, the cause was identified. The cure--the handle of the paint scraper was redesigned. The result--the workers spent more time per day in productive activity; thus, the output and economy of the operation increased, while at the same time, because of diminished risk exposure, the accident rate returned to normal.

Whenever the frequency of occupational ill health or accidents increases after a manufacturing process has been in safe operation for some time, the following question should be asked: what change in equipment, product design, tools used, working population employed, or work method applied has taken place immediately before the breakdown of occupational health?

The change-based accident analysis worksheet (Figure 3) provides examination of 25 potential factors, but even that number is not fully definitive, and the analyst should not hesitate to add to the list as

Change-Based Accident Analysis Worksheet

Subject ____________________

Factors	Present Situation?	Prior, Comparable?	Differences?	Affective Changes?
What Object(s) Energy Defects Protective Devices				
Where On the Object In the Process Place				
When In Time In the Process				
Who Operator Fellow Worker Supervisor Others				
Task Goal Procedure Quality				
Working Conditions Environmental Overtime Schedule Delays				
Trigger Event				
Managerial Controls Control Chain Hazard Analysis Monitoring Risk Review				

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Figure 3. Change-Based Accident Analysis Worksheet. The factors are only suggestive, and the worksheet is not a form to be completed. Analysis is done with a blank sheet, ruled as in the figure, and tabs modified to fit the event.

the actual event dictates. Figure 3 provides a basic format for change analysis. This format is intended to provide general guidance and suggestions in exploring potential affective changes which might be contributory to this accident. Figure 3, as presented, will seldom be used to tabulate the analyst's findings. Large easel or desk pad pages, ruled in column format, can be used as worksheets.

Initially, the findings and comparisons do not come out in logical or subject order from various witnesses and documents. Rough notes can then be reorganized on a sheet with rows similar to Figure 3, but modified to fit the event. Headings which reflect a time or process often improve the analysis.

The first three columns, the present and prior situations, and their differences (regardless of potential effect), should usually be completed prior to completing the fourth column which represents judgments as to whether the changes affected the accident itself. Be flexible. In the columnar spaces the characteristics of the accident/incident situation should be specified as precisely as possible:

1. Consider present situation (accident/incident situation).

2. Consider prior situation (or most nearly comparable situation).

3. Compare the two to detect changes or differences.

4. List <u>all</u> the differences without evaluation or value judgment or significance (seemly insignificant differences can work together to cause serious problems or accidents) and obscure causes can emerge! So list <u>all</u> differences.

5. Analyze the differences for effect on causing the accident/incident, looking for both independent and collective contributions and not overlooking <u>inter</u>faces.

CHANGE ANALYSIS SCHEMATIC

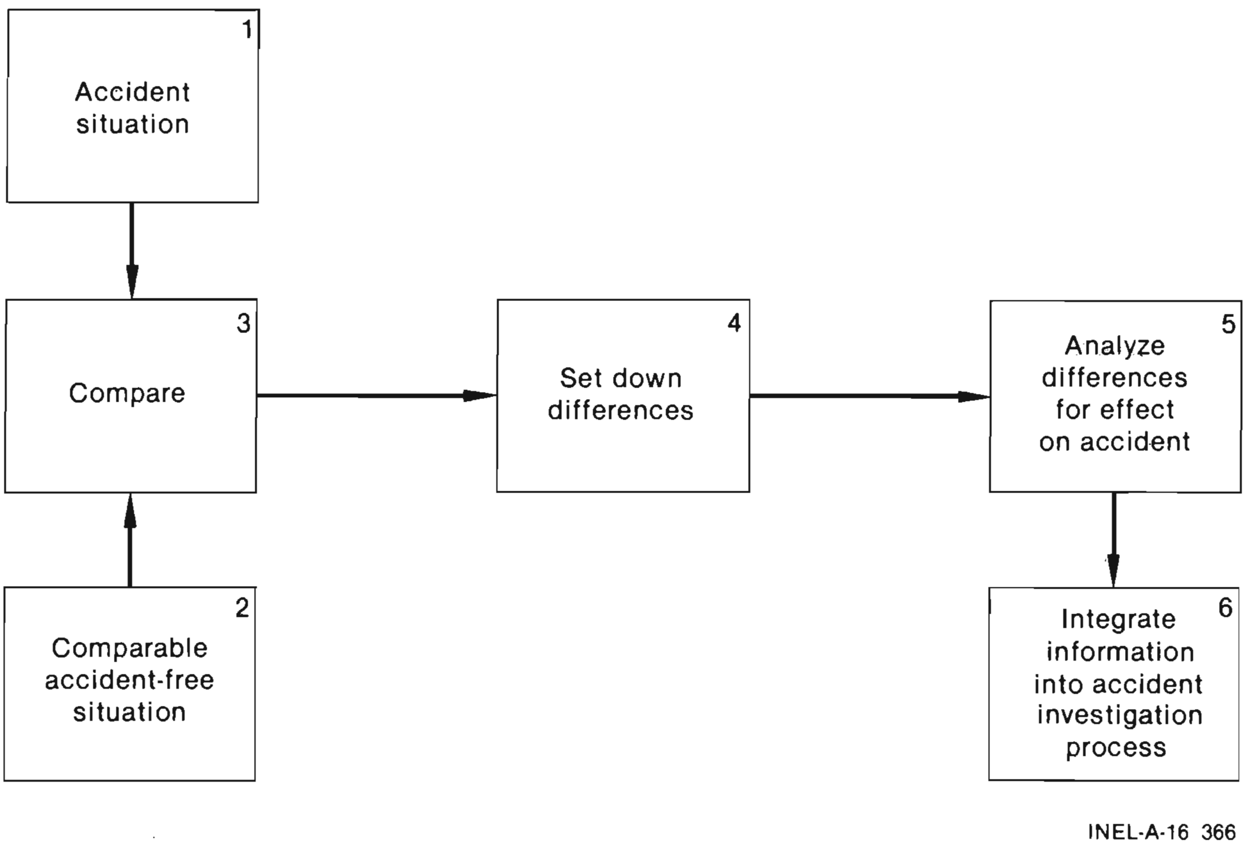

Figure 4. Change Analysis Schematic -- the six steps in change analysis.

6. Integrate the information relative to causal factors into the accident/incident investigation or system appraisal process.

So that is it - a simple 6-step process to analyze and integrate the results into your system improvement efforts. This process is indicated schematically in Figure 4.

Also, one needs to consider the use of different reference bases for analyzing different aspects of the same accident. For example:

- Compare the accident situation with a comparable hardware and operating situation up to the point of accident initiation.

- Comparison with another accident situation; for example, one in which emergency action-amelioration was handled well for purposes of evaluating deficiencies in the emergency action-amelioration phase of the accident.

In seeking relevant distinctions, it is productive to compare the present problem in terms of the same object the day before, the week before, the month before, the year before. At first, the question "How is this different from the week before?" seems a little silly. But, when the distinctions and changes emerge, they often prove to be important.

When causes are not easily perceived, the visibility given by the matrix to known information allows analysts to exercise their knowledge or expertise in identifying causal factors. If possible, however, experimental verification of cause is recommended.

The final draft of the change analysis is often useful in the Accident/ Incident report. It may succinctly summarize events. It may also be the outline form for the narrative. Or, it may be carried over to be expressed in a sequence diagram as shown in Figure 5.

SEQUENCE DIAGRAM

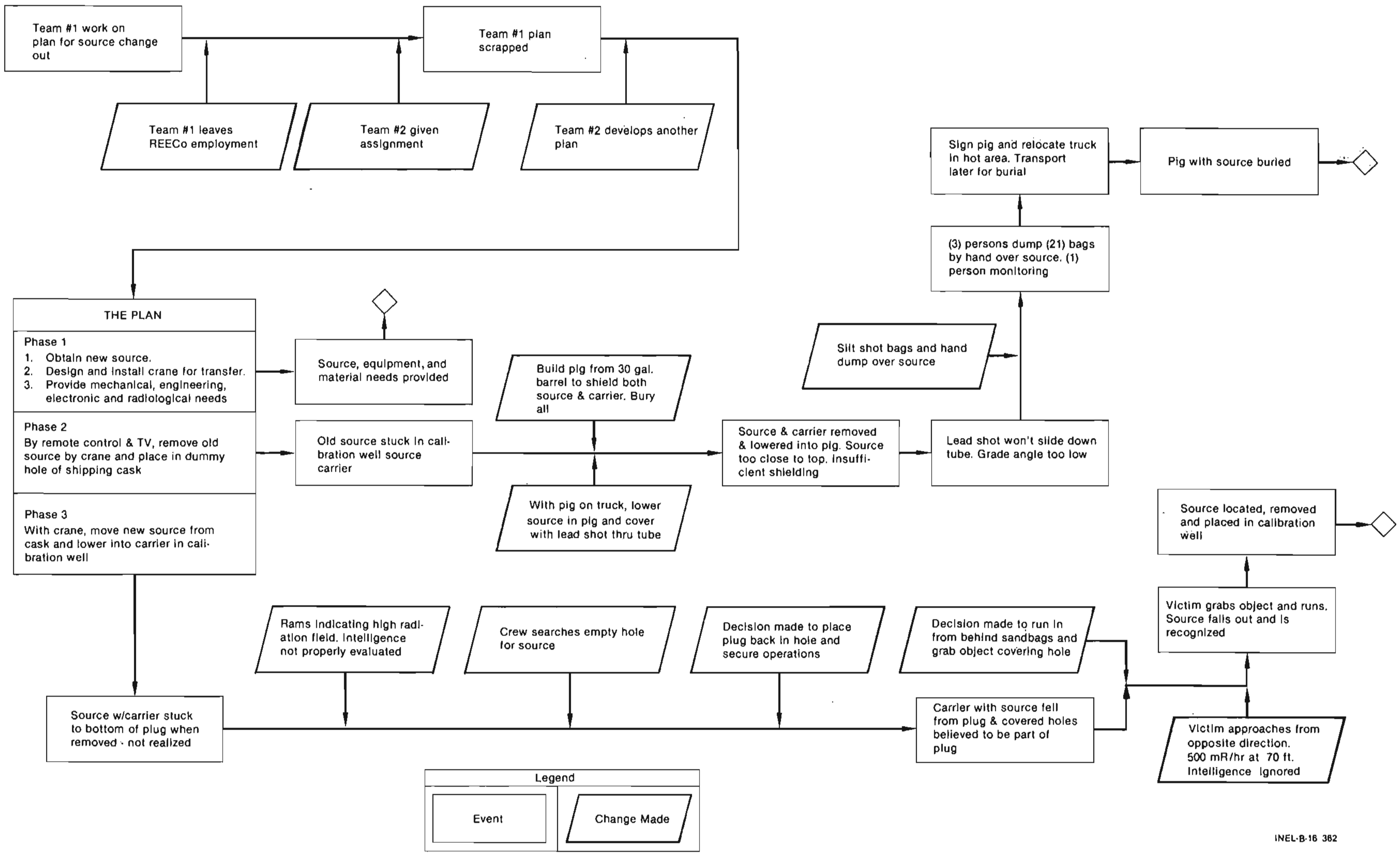

Figure 5. Sequence Diagram with Change Analysis Incorporated

Figure 5 describes a radiation exposure incident in which the sequence of events contained many uncontrolled changes which contributed to the problem situation.

When this method was used in the analyses of routine accident reports from a number of corporations to detect the role of change, it yielded two types of results:

- Most reports were grossly deficient in identifying changes that contributed to the series of events that resulted in the accident. The report forms did not ask the pertinent questions.

- Where reports were, by chance, complete in the narrative section, the number of changes identified were so great, it was amazing that the accidents were not more severe.

The change analysis, in its basic form, defines and treats Accident cause. Each problem must be defined and isolated for examination. Experience in safety has shown that there are usually multiple causes in accident/incident investigation and this must be kept in mind. Each deviation (change) must be separately and precisely defined; described by identity, location, time, and extent -- the what, where, when, and how questions must be answered. This is most easily handled through a tabular matrix, as illustrated in Figure 3. Most accident reports lack sufficient identification of change and differences because the report forms are not designed to ask the questions: who, where, what, when, how, and especially the why?

Let us examine a case study where all these questions are answered in the analysis, on the basis of nature rather than the person's name, machine serial number, etc.

AL OF IMC CASE STUDY[5]

Al was employed by the International Manufacturing Company which employed 450 people. IMC was the only large company in the community of 16,000. It started 22 years ago as a manufacturer of lawn mowers. Twelve years ago, it had expanded to a line of six mowers to include self-propelled and riding mowers. Eight years ago, IMC added a line of garden tractors and built a large addition to the plant, and three years later began an alternate season production of snowmobiles.

Al had worked for the company for two years, since his graduation from high school. He was a general machinist, and his job had been deburring machined parts for the garden tractors and snowmobiles. The parts were brought in bins to his station by a lift truck. After finishing them, he placed them on a conveyor which transported them to the assembly section. Al was an eager, above-average worker. He often finished his parts ahead of the delivery of a new bin, and would help others or would visit with other workers when supervisors were not around. Company rules prohibited visiting other stations as a safety precaution, and all workers were told of this rule. Al's work was always high quality, and he was transferred to the Product Development Section to do machine work for senior employees developing model changes in mowers.

Al was sharpening a blade for the IMC grounds maintenance mower as a favor to a friend. As he pressed the blade to the grinding wheel, it dug into the abrasive wheel and a piece of the wheel flew into Al's eye. He was taken to the company doctor's office in town for treatment but lost sight in the eye. Following the initial chip flying off the wheel, a large piece of the grinding wheel was thrown out. This piece pierced the radiator of a grounds maintenance garden tractor which had been driven to the shop to bring the dull blade for sharpening.

The supervisor, Bob, submitted a report stating that Al had been injured due to failure to use eye protection as required by company rules. All company employees were read an announcement of the accident at the next weekly safety meeting and told to be sure to use their protective glasses or shields.

In checking the cost of the radiator to complete the report, the Personnel Manager, who had responsibility for safety, learned that the mower was damaged further in moving it to the maintenance shop.

The following is a commentary of the analysis process which took place, with the findings tabulated in the matrix in Figure 6:

A. Who? It is important not to confuse the people who are the source of change with the change itself. In identifying and describing the people, they should be fitted to the worksheet in three categories: upper and middle management, staff and first-line management, and operators or workers. A fourth category of others involved--onlookers, visitors, and similar people not working in the process--may contain sources of change or influence.

   One of the natures of people which should be inserted in the analysis matrix is functional training and qualification--as manager, supervisor, or worker. Personal natures of proficiency, recency of job

Figure 6. Change-based Analysis Worksheet for AI of IMC Case Study

		IDENTIFYING ASPECTS	EXCLUSION OR OMISSION	DISTINCTIVE CHARACTERISTICS	CHANGE
WHO	*Worker*	*2 yrs. experience* *High quality performance*	*Not trained on grinder* *No transfer job orientation*	*Young, general machinist in section of older workers*	*New transfer to specialized work*
	Supervisor I	*Long term with company. Progressed to position*	*No supervisory/management training*	*Gives full attention to design problems*	*None*
WHAT	*People* *Equipment* *Material* *Environment*	*Regular operator* *Low speed grinding wheel* *Mower blade being sharpened*	*Not wearing eye protection* *Not high speed compatible with machine* *Not regular section work*	*Routine disregard* *Newly installed* *Not controlled by supervisor*	*Violation of Standard* *Wrong type from parts supply* *Normally sharpened in maintenance shop*
WHERE	*On Object*	*Low speed wheel on high speed grinder*	*No deviation in other sections or shops*	*Change made by operator*	*Replacement normally done by maintenance.*
	In Parts Bin	*Separate bins for low and high speed wheels*	*Not visually distinguishable*	*Returned parts not marked.* *Moved stock recently*	*Requisition of low speed machines resulted in dual stock*
WHEN	*In Process*	*Fracture at first contact*	*Not after wheel had been used or in use*	*Contact with energy source*	*Blade not supported by tool rest*
	In Time	*Second week after operator transfer*	*Not established employee in work section*	*No behavior reinforcement from section*	*Loss of motivation from peer group*
HOW MUCH	*Use of Grinder*	*Normal procedure for other routine work*	*Other use not prohibited in standards*	*Normally used by operator*	*Work not approved by supervisor*
	Use of Mowing Tractor	*Used as personal transportation*	*Not prescribed use*	*General misuse practice*	*Abuse subjected tractor to damage*
PERSONAL FACTORS	*Lack of Knowledge*	*Operator not trained on equipment or personal protective equipment.* *Developed operator skills had no transference to maintenance of equipment.*			
	Improper Motivation	*Prestige of job not self evident. No behavior reinforcement for operator.*			
JOB FACTORS	*Inadequate Standards* *Inadequate Design* *Normal Wear* *Abuse*	*Eye shields & personal equipment standards & enforcement inadequate.* *Grinder wheel interchange possible. Purchasing standards deficient.* *Maintenance schedules not established for grinder or tractor.* *Placed tractor in area where subjected to damage.*			
WHY?		*Job instruction deficient; no task analysis; Inadequate selection & training program.* *Inadequate maintenance & inspection; Inadequate inspection program.* *Uncontrolled acts; Inadequate programs for job analysis; standard job procedures; job enrichment; and job observation.*			

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performance, observation and evaluation, and normal work capacity should also be included. Relevance to the work situation of the accident would define the nature of either visitors in the area or employees who were onlookers at the moment. Other factors might be distractions or interference they might induce by their presence.

Placing the factors from the "Al of IMC" accident scenario in the Who matrix tabulates the following information:

Worker:

<u>Identifying aspects</u> - 2 years experience, eager, high-quality performance worker, generally ignored personal eye protection.

<u>Exclusions or omissions</u> - Not trained on grinder, no job orientation in new position, no job safety training other than weekly 5 minute meetings.

<u>Distinctive characteristics</u> - Young, general machinist in section of older designers and engineers.

<u>Change</u> - New transfer from production group to specialized work.

Supervisor 1:

<u>Identifying aspects</u> - With company since founded progressing from machinist to design chief.

Exclusions or omission - "Became" supervisor of section with seniority. No supervisory/management training.

Distinctive characteristics - Jumps into design problems with his full attention.

Change - None.

Visitor:

Identifying aspects - Visitor to shop. Came to get blade sharpened because maintenance was busy. He knew Al personally. Used mower as "taxi".

Exclusions or omission - No knowledge of machinist work, mower care use.

Distinctive characteristics - No real motivation.

Change - Use of mower as personal transport to inappropriate work area.

Supervisor 2:

Identifying aspects - Supervisor of Maintenance. With company since founded progressing from maintenance to foreman.

Exclusions or omissions - No supervisor/management training.

Distinctive characteristics - Regarded grounds maintenance as insignificant part of job. Kept production machines in good condition.

Change - Condoned abuse of mower as taxi around plant.

B. What? Identifying the deviation and the distinguishing features is a critical part of change-based analysis. The object, tangible or intangible, in which the deviation appears must be identified precisely. Deviations in or on people, equipment, material, and environment can all be placed in the matrix for analysis. In the illustrative case, the entries would be:

People:

Identifying aspects - Regular operator of grinder.

Exclusions or omissions - Not wearing eye protection.

Distinctive characteristics - Disregard for personal safety practices routine.

Change - Violation of standard.

Equipment:

Identifying aspects - Low-speed grinding wheel.

Exclusion or omission - Not high-speed grinding wheel.

Distinctive characteristics - New wheel, recently installed on the older machine.

Change - Wrong type of wheel installed in recent change of grinding wheel.

Equipment:

Identifying aspects - Protective shield for model grinder.

Exclusion or omission - Removed from grinder.

Distinctive characteristics - No power interruption switch or lockout. Shield scratched and greasy.

Change - Violation of standard in removal. Lack of standard for cleaning.

Equipment:

Identifying aspects - Tool rest on grinder.

Exclusion or omission - None.

Distinctive characteristics - Clearance 1-1/4 inch from wheel.

Change - Not reset when wheel changed. Violation of standard.

Material:

Identifying aspect - Mower blade being sharpened.

Exclusion or omission - Not regular section work.

Distinctive characteristics - Not work controlled by supervisor.

Change - Normally sharpened in maintenance shop.

C. _Where?_ Identifying the precise location of the deviation, where it occurs in physical location as well as within the work process, is important in the change analysis. Location of the deviation helps define the true problem.

Placed in the change-analysis matrix, the information obtained from the evidence looks like this:

On Object:

Identifying aspect - Low-speed wheel on high-speed grinder in Product Development Section.

Exclusion or omission - Deviation not found on grinders in maintenance or production sections.

Distinctive characteristics - Wheel in Product Development changed within section.

Change - Replacement of wheels in other shops performed by maintenance.

This information leads to analysis of grinding wheels at the source of supply - the location within the process.

In Parts Bin:

Identifying aspect - Separate bins for low-speed and high-speed wheels.

Exclusion or omission - Not visually distinguishable after removed from package with label.

Distinguishing characteristics - Returned parts are not repackaged before placing in bin.

Change - Recent acquisition of low-speed grinding machines resulted in stocking of low-speed wheels.

D. When? Time is often a critical factor in analysis. Many times, events must occur at precise points in a sequence. In other cases, identifying the time a deviation or deficiency occurred provides a clue to the change which influenced the situation.

The information obtained from the case study fits this part of the matrix as follows:

In Process:

Identifying aspects - Fracture of wheel occurred at moment of first contact with mower blade.

Exclusion or omission - Not late in process after some successful work.

Distinctive characteristics - Contact with energy source.

Change - Blade not supported by tool rest, pulled into wheel.

In Time:

Identifying aspects - Second week after transfer to Product Development.

Exclusion or omission - Not established employee in work section.

Distinguishing characteristics - No behavior reinforcement from senior employees.

Change - Loss of motivation from peer group. Source of motivation in friend seeking assistance in mower maintenance.

E. How much? The extent of the deviation is the final element of the basic information. The amount of deviation can further define the change which created the problem or loss, and help structure the hypothesis as to the causes of the accident. A large deviation from a standard implies that a program is more out of control than would be indicated by a small deviation.

The comparison between the two is illustrated in this case study as follows.

Use of Grinder:

Identifying aspects - Normal procedure for other work.

Exclusion or omission - Is not prohibited in standards.

Distinctive characteristics - Grinder used to do normal type of work by normal worker.

Change - Performed work not assigned by supervisor.

Use of Mowing Tractor:

Identifying aspects - Used as a vehicle for transportation.

Exclusions or omissions - Is not prescribed use of mowing tractor.

Distinctive characteristic - General practice in violation of standard.

Change - Condoned abuse subjected tractor to damage.

F. Identification of personal factors. Completing the change analysis leads to identification of factors through iteration, or going back to search for evidence which explains or defines parts of the problem. The initial fitting of information to the matrix will probably raise more questions than it answers. Through seeking additional information to complete the matrix, the definition of the problem takes shape. Once the problem is precisely defined, it can then be solved through breakdown of the Personal Factors and the Job Factors. The Personal

Factors which might contain the origins of the basic causes are: (1) lack of knowledge or skill, (2) improper motivation, and (3) physical or mental problems.

In this case study, the change-based analysis identifies both the first two factors. The operator did not receive precise training in either the use of the equipment involved or in the use of personal protective equipment. He developed operator skill which had no transference to maintenance such as the changing of the grinding wheel and resetting of the tool rest. The motivation of assignment to what executives considered a prestige job was considered self-evident and not pointed out to Al. His real motivation was in excelling among his peers. Once removed from the work section by transfer, this motivation was lost until restored in the friend's request for assistance. The job environment of development work with older workers held neither social nor prestige conditions for positive behavior reinforcement for Al.

G. Identification of job factors. The second major group of basic causes of accidents are the job factors which are the origins of substandard conditions in the workplace. The five categories of job factors are: (1) inadequate work standards, (2) inadequate design or maintenance, (3) inadequate purchasing standards, (4) normal wear and tear, and (5) abnormal usage, or abuse.

In this case study, the change-based analysis matrix leads to identifying the following with respect to these job factors:

(1) Standards for use of eye shields or personal protection were inadequate and compliance enforcement was inadequate.

(2) Design of grinder permitted interchange of wheels. Maintenance schedules and performance prompted removal of eye shield due to unserviceability, tool rest out of adjustment, and replacement of grinding wheel by operator rather than by equipment maintenance.

(3) Purchasing standards allowed purchase of equipment which was incompatible, and thus the inappropriate interchange of parts.

(4) Wear not considered, and tractor maintenance schedule not established.

(5) Abuse of tractor placed it in position to suffer damage from grinding wheel.

H. <u>Why</u>? Identification of personal and job factors through change analysis leads, through iteration, to revelation of causes. As each element is filled in the matrix, the investigator should ask the questions, "What is the change in this?" and "Does this tell me why there is a problem?" The questions should guide the analysis to identify first the symptoms, then the basic causes, and then the reasons why the program is out of control.

In the case study, we are led to the following:

(1) Eye-protective goggles were not used because the training program was deficient. The program did not include instruction on use of equipment. This, in turn, resulted from deficiences in job-task analysis and deficiencies in work observation. These now trace to deficient supervisor training, which resulted from an inadequate personnel program for selection and training.

(2) The eye shield became unusable, the tool rest was out-of-adjustment limits, and the grinding wheel improperly replaced due to an inadequate maintenance program. All this resulted from a deficient inspection program and standards.

(3) Improper parts were installed due to lack of a program to identify and correctly stock replacement parts. Errors in the stockroom went unnoticed due to deficiencies in the inspection program and materials program.

(4) Uncontrolled acts were performed in the work section due to lack of programs for job task analysis, development of standard job procedures, and job enrichment.

(5) Secondary damage losses were incurred due to lack of control of compliance with standards, which resulted in the tractor being driven into the shop where it was hit by parts of the disintegrating wheel.

Through the discipline of the analysis matrix, the change-based analysis can lead to a thorough examination of deficiencies, introduced by changes in the following elements: personnel, plant and hardware, procedures and managerial controls.[4] Changes from a previous no-accident experience are often subtle, but the information is there for the investigator who constructs the analysis carefully.

V. CONCLUSION

Remember - change analysis is not only done after-the-fact, but should also be used to preclude problems. In this text, you were shown several matrix-type change-based analysis worksheets which all seem to work equally well. Perhaps you as the analyst can develop one which might be better suited for your system and problems. It is not important which change analysis method is used, only that the analysis is made.

In summary, we have learned by sad experience that errors (unsafe conditions and unsafe acts) are before-the-fact of an accident. It seems further true that "change" is before-the-fact of error. Therefore, an ideal managerial system would incorporate change identification and control.

VI. REFERENCES

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APPENDIX A

REECO CHANGE ANALYSIS WORK SHEETS[3]

APPENDIX A

The following is the commentary which goes with the REECO Change Analysis Work Sheets.

There are six major elements which need to be considered when developing a change analysis. These are: 1) Job Statement; 2) Factor; 3) Current Method; 4) Change; 5) Adequate/Less than Adequate; and 6) Action Required. An explanation of each consideration with an example is included here as an aid to the analysts.

Job Statement

The Job Statement has three questions the analysts must answer in order to assure that there is a need for a change analysis. These are: 1) Current Method, i.e., What is the current procedure, method, activity, task, etc.?; 2) Change, i.e., What change in the current procedure is evident that would make the analysis necessary?; and 3) Why change is necessary/desired? A brief statement of why this change is necessary, i.e., Proposed change in a system, or a change to prevent accidents, etc.

Factor(s)

Factor(s) are those items or activities that could cause system problems including an incident or accident if change occurs in a system. The present analysis form identified 12 factors that could contribute to the potential for an accident/incident situation. Under each of these factors is a list of words that describe the factor. These words are "Memory Joggers." They are not complete and should be extended to the analyst's satisfaction.

Examples of questions posed by the factor column are:

1. Communication - What are our means of communication? i.e, verbal, written, radio, telephone, other?

2. Energy - What type of energy do we presently use to perform the activity? How much do we use? Where and/or how do we get more?

3. Equipment - What size, history of downtime, backup, etc?

4. Location - What is our current location where the tasks have been performed without incident?

5. Personnel - How many and what kinds of personnel are being used now and what will be the need or situation where change occurs?

6. Procedures - What procedures are we using currently and what is needed if we are to change from our present operation?

7. Protective Devices - What "Safety" devices, i.e., clothing, tools, equipment, etc., are we now using? Will the change require additional protection? Will it require a different kind of protection?

8. Schedule - Under our current operation, are the schedules realistic? Will the schedule be different when the desired change occurs?

9. Subcontractors - Will we be using the same contractors after the change? Will they perform the same functions? Are there reasons to suspect their operation will be different? If a different subcontractor will be used, what criteria was used in selection?

10. Time - Under our current methods of operation vs. the change, would time be a factor in the change? If time is a change, what is different in the work process?

11. Tools - What type of tools do you use now? Will the same tools be used after the change? If we have special tools, do we have an adequate supply?

12. Weather - What are the current weather conditions? Will there be a decided change when the proposed operation is in effect?

Current Method

This column should contain a brief description of the current modus operandi and should relate to the factor being evaluated (i.e., 02 Energy 04 type - we are presently using electrical energy from an independent supplier).

Change

Change should note the difference (if any) between current method and proposed change, i.e., if the current method of energy is being supplied by an independent supplier and the proposed change (in the Job Statement) would exclude this procedure, then the change would be electrical energy from another source.

Adequate/Less Than Adequate

This column is used by the analysts as an evaluation of both the current method and the change (if any). A less than adequate check ( ) will always require a statement in the Action Required Column.

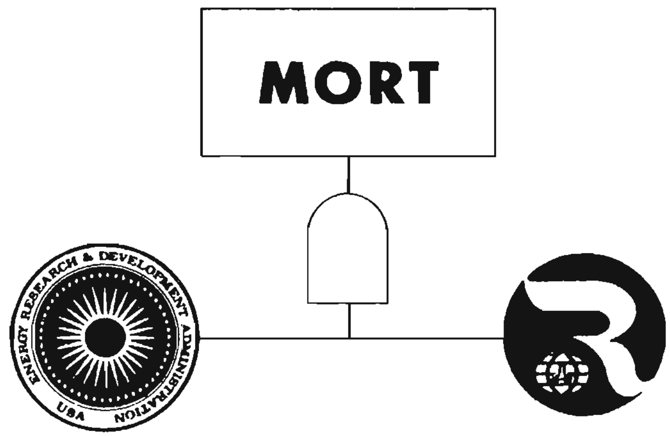
Action Required

Action Required Column should include a statement explaining the actions needed to assure the analysts the change from the current method has been satisfactorily offset.

DEPT:____________________

DATE:____________________

CHANGE



ANALYSIS

MORT CHANGE ANALYSIS

JOB STATEMENT

1. CURRENT METHOD:
2. CHANGE:
3. WHY CHANGE IS NECESSARY/DESIRED:

DEPARTMENT________________________
DATE________________________

Factor			Current Method	Change	Adequate	Less Than Adequate	Action Required
01		COMMUNICATION					
	01	Verbal					
	02	Telephone					
	03	Radio (Net)					
	04	Written					
	99	Other					
02		ENERGY					
	01	Consumption					
	02	Regeneration					
	03	Supply					
	04	Type					
	99	Other					

Factor			Current Method	Change	Adequate	Less Than Adequate	Action Required
03		EQUIPMENT					
	01	Approved					
	02	Downtime					
	03	Life Span					
	04	Weather Effects					
	05	Size					
	06	Backup					
	07	User					
	99	Other					
04		LOCATION (Geog.)					
	01	Altitude					
	02	Forrested					
	03	Geology (Soil)					
	04	Hilly					
	05	Marshy					
	06	Mountainous					
	07	Rocky					
	08	Sandy					
	09	Watery					
	10	Desert					

Factor			Current Method	Change	Adequate	Less Than Adequate	Action Required
	99	Other					
05		**PERSONNEL**					
	01	Craft(s)					
		A. Journeyman					
		B. Apprentice					
	02	Supervision					
	99	Other					
06		**PROCEDURES**					
	01	Approved					
	02	Written/Verbal					
	03	Specialized					
	04	Timely					
	05	MORT					
	06	JSA					
	99	Other					

Factor			Current Method	Change	Adequate	Less Than Adequate	Action Required
07		PROTECTIVE DEVICES					
	01	Availability					
	02	Requirements					
	99	Other					
08		SCHEDULE					
	01	Approved					
	02	Realistic					
	99	Other					

Factor			Current Method	Change	Adequate	Less Than Adequate	Action Required
09		SUBCONTRACTORS					
	01	Company Procedure					
	02	Production Capability					
	03	Responsibility					
	04	Safety					
	05	Size					
	99	Other					
10		TIME					
	01	Night					
	02	Day					
	03	Morning					
	04	Afternoon					
	05	Evening					
	06	Winter / SP / SU / Fall					
	99	Other					

		Factor	Current Method	Change	Adequate	Less Than Adequate	Action Required
11		TOOLS					
	01	Availability					
	02	Power					
	03	Specialized					
	04	Wear Rate					
	99	Other					
12		WEATHER					
	01	Cloudy					
	02	Cold					
	03	Dry					
	04	Dusty					
	05	Hot					
	06	Humid					
	07	Rain					
	08	Snow					
	09	Sunny					
	10	Windy					
	99	Other					

PREPARED BY

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REVIEWED BY

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SSDC-8	Standarization Guide for Construction and Use of MORT-Type Analytic Trees
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SSDC-10	Safety Information System Cataloging
SSDC-11	Risk Management Guide
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