Information Circular 9438

A Review of Job Analysis Methods

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This report has been technically reviewed, but it has not been copy edited because of closure of the agency.

CONTENTS

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By Joan K. Kuenzi[1]

ABSTRACT

The purpose of this U.S. Bureau of Mines information circular (IC) is to discuss how job analysis methods taken from different disciplines can be used together to form a more complete picture of jobs in the mining industry. "Job analysis" is a term used by many researchers, but use of the term is far from standardized. Authors of papers on this subject often state that there is confusion in how or why jobs are to be analyzed, what the resulting information is to be used for, and what the "job analysis" actually means. The process of breaking a job into elemental tasks and analyzing them is used to determine what skills and knowledge are needed to perform a given job, to improve efficiency, and to develop safer job procedures. All are valid reasons to analyze jobs, but the methods used to accomplish the analyses may be very different. In order to create a more complete picture of a job, it may be useful to incorporate methods and information from different areas of study rather than choosing one method for analysis.

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INTRODUCTION

The purpose of this IC is to discuss how job analysis methods taken from different disciplines can be used together to form a more complete picture of jobs in the mining industry. The term "job analysis" can be a method of breaking a job into tasks in order to find out the hazards involved, or a way to select tasks for combination or automation as jobs change with technology. Methods used to analyze jobs from different viewpoints will be presented to give readers a choice of job analysis alternatives for use in their own companies. This work stems from a cooperative agreement with two surface mine sites to provide job analysis training and technology transfer as a part of a mine maintenance safety research program.

One thing that is readily apparent in the job analysis literature is that there is no single definition for "job" or "task" or "work" analysis. Research on the subject can be found in management, personnel relations, psychology, and engineering arenas. All have different ideas on what a job is. Bringing information for these different disciplines together may provide a clearer picture of a job.

What is a "job?" It is important to define what a job is in order to analyze it. The following are three accepted definitions for consideration. First, According to the Job Safety Analysis manual published by the Mine Safety and Health Administration (MSHA), a *job* is "...used to describe a single *task* or *operation* a worker does as part of his or her occupation; it is a definite sequence of steps or separate activities that lead to the completion of a work goal."(*1*)[2] Second, however, the Revised Handbook for Analyzing Jobs published by the Department of Labor states that a *job* is very different from a *task*. In this definition, a job is made up of tasks, which in turn are made up of elements, and an occupation is a grouping of jobs (*2*). Third, in Functional Job Analysis, the *job* is divided into *functions*, which are then further divided into tasks (*3*).

Job Safety Analysis, Functional Job Analysis, and Task Analysis are all different names for basically the same thing. All aim to break out the parts of a job or task and look at each part. They all differ, however, in how jobs or tasks are defined, and what information is gained from the breakdown.

The concept of breaking a job into component parts was used to increase efficiency in the job before being used to decrease the risks. In 1911, F. W. Taylor published his essay on scientific management based on principles he formed while working with pig iron handlers (*4*). One of the main elements of this work was the idea that one could break apart a job and look at each element individually to make it more efficient.

Also, in the early part of this century, the introduction of state workers' compensation laws in Wisconsin and New York prompted the emergence of safety engineering and accident prevention as professional safety disciplines in the United States. Job analysis has been recognized as an integral feature of the industrial safety effort throughout the development of these disciplines. The following subsection reviews the safety engineering and the Mine Safety and Health Administration (MSHA) approaches to job analysis in order to compare and contrast the methodology employed in these approaches with that presented here.

EARLY APPROACHES TO JOB ANALYSIS

The safety engineering approach to job analysis was born out of the work of H. W. Heinrich in the 1930's. In his book, Industrial Accident Prevention, he states that job analysis is the process of investigating the peculiarities of a given job and then selecting the worker who fits those peculiarities for the job. This he called: "fitting the job to the man rather than fitting the man to the job" (*5*). These two concepts, "fitting the task to the man" and "fitting the man to the task," are now thought of as ergonomics and worker selection, respectively. By determining the hazards that were part of the job, workers could be trained in how to avoid them. Heinrich wrote that ten percent of all accidents could be attributed to machines, dangerous substances, improper personal protective equipment, and environmental factors. The other eighty-eight percent were cause by "...moral or supervisory failure." (*5*) This was evidenced by cases where there was unsafe material handling.

In this approach, once the job was analyzed and the hazards determined, two methods were used to help prevent accidents; improving methods and procedures or providing the correct amount of supervision.

M. A. Gimbel, like Heinrich, wrote that once the job had been analyzed, job requirements were to be given to personnel. Employee selection, based on those requirements, was then made (*6*). Gimbel added information regarding repetitive versus non-repetitive jobs to his analysis. For non-repetitive jobs such as maintenance, the analysis resulted in a more global description of the work, whereas

[1]Italicized numbers in parentheses refer to items in the list of references at the end of this paper.

the analysis of repetitive jobs focused more on specific handling instructions. All the initial aspects of job analysis discussed above were the duty of the foreman, not the safety professional. It was the safety professional's job to observe the employee on the job and modify or eliminate hazardous movements, or provide safety devices. This was called "on-the-job analysis."

MSHA's WORK IN JOB SAFETY ANALYSIS

Mining companies are most likely acquainted with Job Safety Analysis or JSA (*1*). JSA is one method of dissecting a particular job. In JSA, jobs are broken down into tasks, the hazards for those tasks are identified, and then the identified hazards are controlled. The JSA guide provides a listing of questions to be used as a guide for assessing the hazards involved in a given job element (*1*). This guide covers the fundamental aspects of conducting JSA's in mining operations for accident prevention (*1*). According to the manual, JSA is based on three ideas: "that a specific job or work assignment can be separated into a series of relatively simple steps; that hazards associated with each step can be identified; and that solutions can be developed to control each hazard" (*1*).

Like Heinrich's, the MSHA approach to job analysis is based on the premise that accidents occur because of unsafe acts or conditions. MSHA goes on to state that the basic causes for accidents can be traced to the policies and decisions of management, and personal and environmental factors. The MSHA method of JSA can be used at each level of accident causation by "...establishing meaningful safety policies, by creating a safety awareness, and by dealing with the personal and environmental factors that lead to accidents" (*1*). This method also aids in the identification of unsafe acts and conditions, and results in information that can be used to train workers, develop safe procedures, and aid in the safe design and maintenance of work stations and equipment. According to MSHA, "The direct cause of most accidents is the unplanned release of excessive amounts of energy or of hazardous materials" (*1*). At this most direct level, JSA looks at these issues and is designed to aid in the reduction of quantities of available energy or hazardous materials. If a reduction cannot be made, JSA method states that all workers must be supplied with the appropriate personal protective equipment, and that emergency procedures will be developed using the information gained from using JSA (*1*).

There are four basic steps in conducting a JSA: [1] select the job that will be analyzed; [2] separate it into its basic steps; [3] identify the hazards associated with each step; and [4] control each hazard. Once the analysis has been conducted, the resulting information is presented in a chart which is then used to train workers, and can be reviewed by workers already familiar with the job.

The jobs to be selected come from two areas: high risk jobs (those having a history of accidents and/or where workers are exposed to hazardous materials or excessive amounts of energy), and newly created jobs. High risk jobs are identified using past accident records from the company, or by locating jobs where there is an excessive amount of energy or where hazardous materials are involved in the work.

Once the job is identified, it is separated into basic steps. These steps describe succinctly what is being done, not how it is done. All steps are recorded in the order they are performed. According to the manual, jobs can usually be separated into 10-15 basic steps, the sum of which describe the work as accurately and completely as possible (*1*).

The analysis uses observational methods to determine the steps involved. These methods include the direct observation of the job, or discussing the job with experienced workers.

After the steps are enumerated, the next step in JSA is to identify the hazards associated with each of the steps. There is a list of questions in the manual to provide guidance in the identification process (*1*). This list covers things such as overexertion, coming into contact with energy or hazardous material; being struck by something, striking against anything, being caught in, on, or between anything, and slipping, tripping or falling.

The last step in conducting a JSA is to control the hazards involved with each step. The manual states that the solution to any hazard will normally be found in one of the four categories: environmental change, job frequency reduction, protective apparel, and job procedures. Examples of environmental changes include providing barricades or shields to get the worker away from hazardous materials or excessive energy; reducing the amount of material or energy; or changing the tools, equipment, or the physical environment involved in the work. Job frequency reduction means reducing the number of times a job is to be performed in a given time period. Protective apparel includes shoes, belts, gloves, respirator, glasses, and the like. Finally, the job procedure category is used for creating descriptions of exactly how the work should be done. After the JSA is completed, the resulting information should be periodically reviewed to insure an accurate, up-to-date picture of the job.

USES FOR JOB ANALYSIS

For the purposes of this IC, the following definitions from the Revised Handbook for Analyzing Jobs will be used: Job: a group of positions in an establishment which are identical with respect to their major or significant tasks, and sufficiently alike to justify their being covered by a single analysis." (*2*). Task: "one or more elements" of a job (*2*).

Uses for job analysis data differ depending on the agenda of the researcher. The following is a list of typical uses for job analysis information generated from the literature:

1. Wage and salary programs (*3*).
2. Career ladder development/vocational counseling (*2-3*).
3. Job restructuring for productivity and job enrichment (*2-3, 7-8*).
4. Occupational safety improvements (*1-3, 8*).
5. Effective manpower utilization/training (*2-3, 7-8*).
6. Affirmative action programs (*3*).
7. Performance evaluation (*2, 7-8*).
8. Preparing better job descriptions for future employee selection (*7-8*).
9. Comparing similar jobs at different locations for standardization (*7-8*).
10. Comparing management and worker viewpoints as to how the job should be performed and comparing that information to standard operating procedures (*7*).
11. Tracking changes to a job over time (*7*).
12. Demographic research (*8*).
13. Organizational relationships (*8*).

Rather than reviewing job analysis from all of these perspectives, this IC will discuss the use of job analysis for health and safety management. Methods traditionally used in the other academic arenas will be presented, along with ergonomic methods (e.g., dealing with the physical attributes of the work system) to illustrate how each can contribute to a successful job analysis.

In the following sections, a number of job analysis methods will be presented. Rather than choosing a single method as the correct one, this report discusses alternative methods that might be used depending on the information desired. For example, a person might use only safety-oriented methods (yielding information about the hazards in the workplace), or integrate a variety of methods (to yield information about how the work is done in other locations with similar equipment, what organizational uses may force workers into hazardous situations, what training materials can help workers to recognize hazards and deal with them, or how to make the job available to a larger portion of the workforce).

No single method is, in itself, a job analysis. The structure of an analysis should include:

1. Methods which break the job into tasks, and the tasks into component parts.
2. Those methods that examine relationships between those component parts and compare that information with correct principles of performance.
3. Attempts to restructure the parts to form an improved job and specify learning requirements (*9*).

These topics are addressed in the following three sections dealing with: [1] defining jobs in need of analysis; [2] breaking the job into component parts; and [3] studying relationships between aspects of the work and the workers who perform that work.

One important point that must be made here is that, with the exception of the definition of job safety analysis adopted by MSHA (*1*), it is generally accepted that a job analysis is not the same as a standardized operating procedure (the accepted procedure for job performance). All job analysis methods are used to update the kinds of information contained in the job's procedural documents (e.g., the tasks involved in the job, the tools needed, the safe operation of necessary equipment, and safety information). However, it is not the job. Job analysis, functional job analysis, and JSA are TECHNIQUES used to take the job apart and systematically evaluate the different aspects, thereby supplying the information used to compose and revise the standard operating procedure.

METHODS OF JOB ANALYSIS

FINDING THE JOB TO ANALYZE

The first methodological challenge in job analysis is selecting or prioritizing which jobs to analyze. This may be accomplished in a number of different ways, as discussed below.

1. Review of Accident Records: this method is used to pin down jobs that may have a higher rate of accidents/injuries in general, or those where a certain type of accident occurs more often. Incidence rates (IR) provide information about the number of cases in a given population over a specific time period (*10*). An IR is usually

computed as the number of cases per 200,000 hours of exposure time.

The IR can be computed many ways; by department, by job title, or by site. Griffith and colleagues[3] computed 3-year IRs both site-wide and by occupation within each site in a study of surface taconite maintenance work. Then, those occupations with IRs that exceeded the site IR were tagged for possible analysis. The occupations which exceeded the site-wide IR consistently for the 3 years were chosen for analysis, and a list of jobs to be analyzed in the future was also generated.

2. Review of Requests from the Dispensary: this kind of information may give the analyst insight into which areas may be experiencing problems that do not result in accidents, but that might be worth looking into. Dispensary requests may be for headaches or soreness related to noise, inadequate ventilation, overexertion, or other work stresses.

3. Review of Production Records: this method is also used to determine jobs to analyze, but from a productivity standpoint. Company statistics such as pieces per area, or product value or weight in a given period of time, could be used. Areas with lower production rates determine the areas to be analyzed to increase the efficiency of the job.

4. Review of the Process: A company can define areas to analyze by diagramming the entire process. The goal of creating process charts or multiple activity charts is to pick apart the process to find areas where: [1] work pile up is causing bottlenecks; [2] there is a lot of waste created by the work; [3] time is wasted; [4] dangerous work conditions exist; or [5] there is a lot of physical work being done (*11*).

GATHERING INFORMATION ABOUT THE JOB AND BREAKING THE JOB INTO TASKS

Once one or more jobs have been targeted for analysis, the next methodological challenge in job analysis is to break apart each targeted job into its component parts or tasks. Different approaches are presented below. This information, in turn, is used to assess possible health and safety risks associated with worker interaction with different parts of a job.

1. Worker Surveys and Interviews: interviews can be open-ended, or focused, and contain questions about what tasks are involved in a given job, what tools and equipment are used for each task, and what information is needed to accomplish the job. Subjects involved in an interview or survey can range from management to line supervisors to workers on the line (*8, 12*).[3,4]

2. Card Sort Technique: documents which describe the job are reviewed, and any tasks encountered are entered onto 3X5 inch cards. These cards are then sorted into sequential order after all cards have been reviewed. A person considered to be a master performer of the job then reviews the cards and their sequence to see that they are correct for the job (*9*).

3. Daily Log Technique: When accident records or other job-related company documents are not available, workers keep a log of their daily activities. From this log, the analyst can get information as to the tasks involved in a given job. The person who records the information according to Carlisle (*9*) is the master performer; however, it may prove useful to have persons of different skill levels record their activities so that differences by skill level may be seen (*9*).

4. Equipment Documentation: Blueprints and specification of equipment used on the job are useful for determining hazards which may be involved due to spatial constraints, interface problems, or maintenance needs. Photographs can be taken of equipment used, and then each piece can be weighed, measured, and catalogued (*8*)[3].

5. Work Area Observation: Observations are made of the work environment and layout. Diagrams are constructed that show where pieces of equipment are located, traffic pattern in the area, and sources of noise. Observations are made of housekeeping in the area, lighting, and access to equipment and facilities.[3,4,5]

PROVIDING INFORMATION ABOUT HEALTH AND SAFETY PROBLEMS OR RISKS IN THE JOB

Once the task structure of a targeted job has been delineated, the final and arguably the most important methodology in job analysis is to ascertain possible health and safety problems or risks associated with worker exposure to, or interaction with, different job tasks or elements. As summarized below, different options are available for collecting this information. An ergonomic approach to job analyses takes into account the interaction of worker performance and physical work design.

1. *OWAS*: OWAS was developed in Finland for the Ovako Öy Steel Company in 1973, and was used as an observational posture evaluation tool during time-motion

[3]Open File Report 39A-94. Ergonomic Analysis of Surface Taconite Maintenance Work by D. A. Griffith, J. K. Kuenzi, T. J. Smith, J. M. Kenney, E. J. Koehler, and P. K. Mathison. 1994, 560 pp.

[4]Kleman, J. E. Differences in the Perception of Ergonomic Inadequacies of Individual Workstations, and the Roles of Perceived Workload, Work Pressure, and Autonomy. unpublished Master's Thesis, Univ. of Wisconsin, Madison, WI, 1989, 171 pp.

[5]Sainfort, P.C., Job Design Theory of Stress; Tests in Automated Offices. Dept. of Industrial Engineering, unpublished Ph.D. thesis, University of Wisconsin, Madison, WI, 1988, pp.

studies in its plants.[3] OWAS has been tested and used mostly in Finland, Germany, and the Netherlands. The characteristics of the method have also seen use in the United States.[3]

OWAS partitions the body into four separate areas: head, upper limbs, trunk, and lower limbs. For each of these areas, one-digit codes are assigned for the different general positions that can be assumed. Using the upper limbs as an example, three positions are coded: [1] both limbs are at/or above the shoulders; [2] both limbs are below the shoulders; or [3] one limb is at/or above the shoulders and one limb is below the shoulders. The one-digit codes for positions of the upper limbs, the trunk, and the lower limbs are linked together into a 3-digit code for a total posture "score." Some have added the head posture to this score. Added to this score is a fourth field indicating the amount of load handled while the person is in that posture. There are 84 basic working posture codes.

The overall code is then assigned to one of four categories of risk based on stress on the musculoskeletal system. These, according to the OWAS literature, are: category 1.—normal posture (postures considered to have no particular harmful effect on the musculoskeletal system); category 2.—postures which have a slight risk of injury (the stress is minimal so that no immediate action is necessary, but dealing with them in the future would lessen the postural demands of the job); category 3.—postures with a moderate risk of injury (the working methods involved should be changed as soon as possible); and category 4.—postures with a high risk of injury (immediate actions should be taken to lessen the occurrence of these postures) (*13, 14*). Refer to Stoffert (*14*) for the matrix of postures and their classification by risk category. Other similar methods are discussed by Chaffin and Anderson (*15*).

2. *NIOSH Work Practices Guide to Manual Lifting* (*10,16,17*): The 1981 guide (*17*) introduced an equation for calculating back injury risk associated with manual lifting, based on the following factors: frequency of the lift, horizontal location of the load, vertical lift distance, and travel distance. The revised version of the guide takes into account asymmetric lifting, and coupling factors (*15*). There is a series of four computations used to determine the lifting index based on the categories discussed above. The first step involves computing a Frequency-Independent Recommended Weight Limit (FIRWL) for each task. This is the acceptable limit for the weight involved in low frequency or one-time lifts. Next, all the tasks are considered together in the computation of the Frequency-Weighted Recommended Weight Limit (FWRWL). This is a representation of the average strength demands of the job. The third step is to compute the Composite Recommended Weight Limit (CRWL). The CRWL represents a load that almost all healthy workers could perform over an 8-hour work day without increasing the risk of injury or low back pain. The last step involves computing a lifting index (LI) for each task.

3. *Anthropometric Studies of the population* (*18-21*)[6]: Anthropometry is the study and the technique of human measurement. It can be used in conjunction with work area observations and measurement to study how well workers actually fit into their work areas. Measurements taken depend on the job to be analyzed, but can include reach envelopes (e.g., over head, to the side, and in front of the body), heights (e.g., back of the knee, hip, seated back, seventh cervical, stature, acromion), body circumferences, and bony protuberances (e.g., nose).

4. *User Comments and Suggestions*: This method can be used both to gather information about the person-job fit, and to assess changes made to a job as a result of job analysis. Workers, labor unions, and management can all participate in this process. The instrument can be in the form of an interview or a questionnaire. The analyst can stress to subjects that anonymity will be maintained, and that results will be taken into account when changes are made to the job.

5. *Hazard Identification Methods of JSA*: This checklist outlines questions about electrical, chemical, and other hazards that may contribute to accidents in the job (*1*).

FOLLOW-UP AFTER MODIFICATION USING RESULTS OF THE JOB ANALYSIS

An important aspect of job analysis is that it is to be used as a process; once a job is modified, the analyst can expect to see changes as a result of the modification. These changes may be beneficial, or they can be detrimental. A number of methods discussed above can be used to monitor possible follow-up effects of job modification.

Accident data, for a period of time (the longer the better) after the job is modified, can be analyzed and compared with data taken prior to the change. Did incidence rates (IR) change? Did the accidents at the job change in terms of body part injured, nature of injury, etc.?

OWAS can be used as a follow-up method for assessing the effects of job modifications. The analysis can be repeated on the modified aspects of the job, and the resulting postures can be coded into the categories mentioned above. The analyst can then look at several things

[6]OFR 162(2)-83. Mining in Low Coal: Volume II-Anthropometry by M. Ayoub, N. Bethea, M. Bobo, C. Burford, K. Caddel, K. Intaranont, S. Morrissey, and J. Selan, December 1981.

including the distribution of posture codes over the four categories, the increase or decrease in the amount of awkward postures (categories 2-4), and where those awkward postures occur (do they occur in the same tasks or different ones now that the job has been modified?).

Follow-up surveys and interview sessions can focus on the changes made to a job (Were the changes good/bad? Did they cause any problems elsewhere? Did they solve the problem?).

DISCUSSION

The preceding sections gave examples of some of the many methods used in job analysis. Job analysis can be used to accomplish a variety of objectives with respect to making work safer and more efficient. The methods chosen should be based on the objectives of the analyst(s).

The strength of the safety engineering approaches is that they utilize the technique of investigating job elements in a systematic way. That provides the road map for using any of the other job analysis methods described above. Heinrich implemented this concept early (*5*), and the Gimbel approach (*6*) provided the safety professional with additional methods to ensure that whomever worked in the job was safer. The JSA method described and used by MSHA (*1*) uses the concept of breaking down a job in systematic manner like Heinrich. Like Gimbel, it adds the method of observation, and the provision that the analyst can modify a job element in a given way to reduce a hazard associated with that hazard.

There are, however, limitations with both the MSHA approach and the earlier approaches of Heinrich and Gimbel. The approach outlined by Gimbel is similar to that proposed earlier by Heinrich in that each used the results of the initial hazard analysis to select the proper worker for a given job. The main concern with these approaches is that they are designed to select a worker based on the constraints of a given job. If one takes into account the decreased availability of younger workers, combined with Equal Opportunity laws and newly mandated principles of the Americans with Disabilities Act, these methods of worker selection may not be the best way to fill jobs vacated either by employee turnover or injury. A more comprehensive approach would be to investigate the hazards with the goal of making the job available to as much of the workforce as possible.

Similar limitations may be cited for the MSHA approach to job analysis. For example, the MSHA JSA manual includes only a partial listing of hazards that may be present. It does not include specific aspects of the work area that may be hazardous (i.e., insufficient lighting, poor housekeeping, organizational demands, or postural demands on the workers). JSA, as described by MSHA, is therefore limited in what information it can provide to whomever conducts the job analysis.

To cite a specific example, it is plausible that jobs selected for analysis on the basis of back injuries could pass the MSHA list of questions without any hazards defined as a result. Thus, overexertion is on the MSHA question list, but only while lifting, pushing, or pulling. What if the worker experienced an injury while in an awkward posture holding an object in place? Or while reaching or bending to get to an object that the worker has yet to lift, push, or pull?

Another example of the limitations of the MSHA listing could be the lack of hazards inherent in an organizational design. One of the basic causes defined by MSHA in the JSA manual is "management safety policy and decisions." Hazards such as increased work pressure and decreased work autonomy should be included on the checklist. Kleman found that workers experiencing a higher workload, decreased autonomy, and increased work pressure were more likely not to notice ergonomic inadequacies in the work areas such as having to maintain a poor posture to get work done[4]. What if the worker is pressured by time constraints, or by conflicting demands from different supervisors? This worker could be in an environment otherwise deemed safe by those conducting the JSA, but, due to pressures imposed by the work, cut corners and experience an injury. Because of problems such as these, readers need to be provided with a variety of sources for job analysis method such as those presented above, so that the limitations can be overcome.

The ergonomic approach to job analysis described in this IC offers a distinct advantage over the earlier approaches as well as the MSHA approach reviewed in the introduction. The main advantage to using an ergonomic approach is that the analyst can choose from many methods, including those used by MSHA and safety engineering, to develop a more tailored protocol with which to analyze a give job situation.

SUMMARY

The purpose of this IC has been to provide the reader with insight into a variety of tools from different fields with which to build on existing methods of job analysis. A review of safety engineering methods for analyzing jobs, and the approach to JSA used by MSHA has been included to provide a base upon which to build a more tailored analysis methodology using the additional tools discussed in later sections of the paper.

It is important to remember that once one change is made to a job, other aspects of the job also may be affected. These also need to be analyzed. Job analysis is a process, not a one-time thing. To be effective, the job analysis must include feedback about the job after any changes are made, and over a period of time.

There are two objectives for doing a job analysis according to McCormick (*8*). The first is to investigate how human talent is being used at work, and the second is to deal with issues such as health and safety, and job satisfaction. In the past, work has concentrated on efficiency. Now research needs to be done on the second of McCormick's objectives.

The approaches described above strive to define how a worker fits into the work from several different viewpoints. These viewpoints look more closely at the health and safety of both the worker and the work area, without losing sight of organizational issues that may have an impact on job satisfaction.

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☆ USGPO 709-009/20,053