

I am submitting herewith a dissertation written by Charles C. Phillips entitled "The Efficacy of Material Safety Data Sheets and Worker Acceptability." I have examined the final copy of this dissertation for form and content, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Human Ecology.

Bill C. Wallace, Major Professor

and recommend its acceptance.

Greg Pitt
Robert J. Purley
Paula Hamilton

**Associate Vice Chancellor and
Dean of the Graduate School**

**THE EFFICACY OF
MATERIAL SAFETY DATA SHEETS
AND WORKER ACCEPTABILITY**

**A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville**

**Charles Clifford Phillips, Jr.
May 1997**

Copyright © Charles C. Phillips, 1997
All rights reserved

DEDICATION

This dissertation is dedicated to my wife, Pat, son, Chris, and daughter, Dior, for their patience, support, and encouragement throughout this lengthy educational experience.

ACKNOWLEDGMENTS

I would like to express sincere gratitude to my doctoral committee members, Dr. Bill Wallace (chairman), Dr. Charles B. Hamilton, Dr. Gregory C. Petty, and Dr. Robert J. Pursley for their guidance and words of encouragement. A special thanks to Dr. Petty for his assistance in instrumentation design and development.

I would like to thank Dr. Ronald Dessart, Dr. James Neutens, and Dr. Charles Bayne for their assistance and advice on experimental design and statistical analysis. To Dr. Barbara Sattler thanks for the early assistance in selecting the area of study. Special thanks to Ms. Debbie Gray for proofreading and administrative assistance necessary for the completion of this dissertation.

I would like to express my sincere appreciation to Dr. Marwan Bader and Ms. Susan Whitson for their assistance in conducting the testing phase of the study.

Thanks to Kearney/Centaur Division of A. T. Kearney, Inc. for permission to use the MSDS Comprehensibility Test in this study. Also thanks to my panel and pilot participants and to the ATLC Union workers without whom the study could not have been accomplished. Further, my appreciation to Dr. Jerry Swanks, Ms. Ann Shirley, Ms. Linda Pierce, and Yvonne Horton for support in conducting this study toward improving the use of MSDSs at the national laboratory.

I would also like to thank my parents, Charles and Buena Phillips, for their

support and confidence in my early years and throughout my educational career. Thanks Dad for the early challenge. To my sisters and brother, Cookie, Michele, and Lanny, I also thank you for your support and interest. To my in-laws, Lisa and Blackie, thanks for your continual encouragement and patience. I also want to acknowledge my aunt Geraldine for encouraging me throughout my life in my academic and career pursuits.

In memory of coach Julius Conn and to coach Charles Nuttycombe, thank you both for teaching me self-confidence, goal setting, and persistence. Also to coach Dave Walker, thank you for the opportunity you provided me many years ago to attend East Tennessee State University where the pursuit towards this degree began.

Finally, I acknowledge Jesus Christ as Lord and Savior and through his grace this achievement was possible.

ABSTRACT

The primary purposes of this study were to determine how well the Material Safety Data Sheet (MSDS) diffused information to workers, compare the efficacy of an OSHA type Form with the Chemical Manufacturer Association/American National Standards Institute (CMA/ANSI Z400.1) structure and the International Chemical Safety Card (ICSC), and determine worker acceptability and understanding of MSDSs at a large national laboratory. The Adoption Diffusion Innovation Theory, Social Cognitive Theory, and Value Expectancy Theory (Health Belief Model) provided the theoretical framework for this research.

An inventory questionnaire and quantitative testing were utilized to gather data from a purposively selected sample ($N = 160$) out of 824 union workers employed at a large national laboratory. Eighteen crafts comprised the 160 workers studied. Instrumentation utilized in the study consisted of a forty-question inventory on acceptability of the MSDS to the worker and a ten-question MSDS comprehensibility test administered to each worker as a pretest and posttest. The workers were partitioned into four groups of forty randomly selected test subjects. The treatments or independent variables, three differently formatted MSDSs, were introduced as references during the posttest. A different format was given to each of three groups and none was provided to the control group. The MSDSs were controlled for level of readability and the specific chemical addressed was the same on all three. Gain scores between the pretest

and posttest were equated to diffusion efficacy of each treatment format.

Relationships between the variables of age, education level, years worked, and number of chemicals used were evaluated for effect on the efficacy of each format.

Descriptive statistics and the chi-square test were used to analyze the inventory on worker acceptability and understanding of the MSDS. Inferential statistics including the t-test, ANOVA, Dunnett's test, Sidak's multiple comparison tests were utilized to determine significant differences in gain scores between pretests and posttests of formats, between formats and controls, and among formats and groups of variables.

Findings disclosed are: (a) the sample population of union workers studied were well trained on the MSDS and understood and accepted them as viable documents; (b) there were however, lesser percentages of workers that needed to be better persuaded to use the MSDS at the national laboratory; (c) all three MSDS formats significantly diffused information to workers, although approximately one third of the information on the forms was not absorbed; (d) the rank order of finish between the three different formats was ICSC, OSHA type Form and CMA/ANSI Z400.1, respectively, however, there were no significant differences in the scores; (e) there were significant differences in how well each form answered specific test questions with the ICSC and OSHA type Form out performing the CMA/ANSI Z400.1 structure.

TABLE OF CONTENTS

CHAPTER I. INTRODUCTION

Introduction	1
Statement of Problem	4
Purpose of the Study	5
Hypotheses	5
Need for the Study	8
Delimitations	10
Limitations	10
Assumptions	11
Definition of Terms	11
Summary	11

CHAPTER II. REVIEW OF LITERATURE

Introduction	13
History of Hazard Information Development	15
Material Safety Data Sheet	18
National MSDS Repository	26
Hazard Information and Workers	27
World Usage of MSDSs or Equivalent	28
Medical Community MSDS Needs	30
Accuracy of the MSDS	33
Studies on Comprehensibility of the MSDS	35
Employee Understanding of the MSDS	39
Summary	42

CHAPTER III. METHODOLOGY

Introduction	44
Selection of Sample	44
Instrumentation	45
Research Design	49
Pilot Study	49
Data Collection and Analysis	51
Summary	57

CHAPTER IV. ANALYSIS OF DATA AND RESULTS

Introduction	58
Research Question One	59
Research Question Two	64
Research Question Three	68
Research Question Four	71
Research Question Five	79
Research Question Six	85
Null Hypothesis One	87
Null Hypothesis Two	87
Null Hypothesis Three	88
Null Hypothesis Four	89
Null Hypothesis Five	92
Null Hypothesis Six	92
Null Hypothesis Seven	93
Null Hypothesis Eight	95
Null Hypothesis Nine	95
Null Hypothesis Ten	96

CHAPTER V. SUMMARY, FINDINGS, CONCLUSIONS, DISCUSSION RECOMMENDATIONS, AND IMPLICATIONS

Summary	101
Findings	103
Acceptability Inventory	104
Efficacy of Formats	106
Conclusions	108
Discussion	109
Recommendations	111
Implications	113

REFERENCES 117

APPENDICES 125

Appendix A. Definition of Terms	127
Appendix B. Approval Letters	134
Appendix C. MSDS Efficacy Inventory	137
Appendix D: Review Panel	143

Appendix E: Pretest and Posttest: Measurement of Comprehensibility	145
Appendix F: Treatments OSHA Type MSDS, CMA/ANSI Z400.1 MSDS, and ICSC	154
Appendix G: Letter Requesting Worker Participation	169
Appendix H: Pilot Results Worker Comments	171
Appendix I: MSDS Test Answer Keys	179
Appendix J: MSDS Inventory and Comprehensive Test	191
VITA	200

LIST OF TABLES

TABLE		PAGE
1.	Average differences in scores between questions for pretest and posttest	53
2.	Job categories of sampled workers (N=160)	62
3.	The t-tests for pretest and posttest average gain scores (N = 40) on three different MSDS formats reported as (NS) not significant or (S) significant	88
4.	ANOVA summary table for experimental design comparing mean gain scores of three different MSDSs	91
5.	ANOVA summary table for experimental design comparing average gain scores of three different MSDSs to a control group	91
6.	Dunnett's test presented as 95% confidence intervals for an experimental design comparing average gain scores of each MSDS to the control group	93
7.	Hypothesis H6, H7, H8, and H9 based on the results of the MSDS inventory and MSDS comprehensibility test	94
8.	ANOVA summary table for experimental design comparing average gain scores of questions 1-9 of the Measurement of MSDS Comprehensibility test for three different MSDSs	98
9.	ANOVA summary table for experimental design comparing average gain scores of question 10 of the Measurement of MSDS Comprehensibility test for two different MSDSs	100

LIST OF FIGURES

FIGURE	PAGE
1. Employers' experience in complying with Hazard Communication Standard training requirements.	3
2. OSHA Form-20, "Material Safety Data Sheet."	19
3. OSHA Form 174.	22
4. Structure of CMA/ANSI MSDS.	23
5. ICSC Form, <u>International Chemical Safety Compilers Guide</u> .	37
6. Randomized Control Group Pretest and Posttest Design	50
7. Type II errors for a two-sided hypothesis test of mean 1 = mean 2 at the 5% significance level with 40 samples from each population.	55
8. Question 1, gender?	60
9. Question 2, what is your age group?	60
10. Question 3, indicate the highest grade level you completed in elementary school, high school, or college.	61
11. Question 4, how many years have you been working at ORNL?	61
12. Question 7, how many chemicals do you use in your job on a weekly basis?	63
13. Question 9, I have seen the following number of MSDSs in my workplace.	63
14. Question 8, I have received training on MSDSs.	65
15. Question 12, to what extent do you think MSDS training provided to you was satisfactory in providing an understanding of the MSDS?	65
16. Question 23, I would like to see an MSDS during job planning.	66
17. Question 24, I would like to see an MSDS during job safety briefing.	66
18. Question 26, I would ask to see an MSDS when first introduced to the chemical.	67
19. Question 27, I would ask to see MSDS after working with chemical for sometime.	67
20. Question 25, I would ask to see an MSDS after the job has started.	69
21. Question 28, my opinion about the MSDS is its words are difficult to understand.	69
22. Question 29, my opinion about the MSDS is it is easy to read.	70
23. Question 30, my opinion of the MSDS is it is not too long to read.	70
24. Question 31, my opinion about the MSDS is it has a confusing format.	71
25. Question 32, my opinion about the MSDS is its symbols are easy to understand.	72
26. Question 11, MSDSs are available to me within the workshift at my worksite.	73

LIST OF FIGURES

FIGURE	PAGE
27. Question 22, I never see an MSDS.	73
28. Question 16, I am provided MSDS during job planning.	74
29. Question 17, I am provided MSDS at safety briefing at the start of the job.	74
30. Question 18, I am provided MSDS when first introduced to a chemical.	76
31. Question 19, I am provided MSDS when a health and safety inspector comes around.	76
32. Question 20, I am provided MSDS after the job has finished.	77
33. Question 21, I am provided MSDS after an accident or spill.	77
34. Question 6a, have you ever requested information on one or more chemicals with which you worked.	78
35. Question 6b, was the information you requested given verbally, written, computer, or all three?	78
36. Question 6c, If the requested information from management on chemicals was written, was it an MSDS?	79
37. Question 13, to what extent do you think MSDSs are satisfactory in providing information to protect yourself?	80
38. Question 6d, did the information answer your questions?	80
39. Question 14, how often do you use an MSDS when working with a chemical on your job?	81
40. Question 10, I have changed to safer actions in my work as a result of reading MSDS information on chemicals.	82
41. Question 33, health hazard number ratings are useful.	82
42. Question 37, health hazard number ratings should be on labels.	83
43. Question 34, health hazard rating numbers are confusing.	83
44. Question 35, regarding health hazard rating numbers, written information would be better.	84
45. Question 36, health hazard rating numbers should be on the MSDS.	84
46. Question 39, in my opinion chemicals can be a threat to your health.	85
47. Question 38, in my opinion chemicals I work with won't effect my health.	86
48. Question 40, in my opinion this whole thing about chemical hazards is blown out of proportion.	86
49. Average gain scores per question for three different MSDSs forms.	90

LIST OF FIGURES

FIGURE	PAGE
50. Average total scores and average total gain scores for three different MSDS forms posttest.	90
51. ANOVA <i>F</i> -statistic values for comparing average gain scores of the three forms for each question. Dash line is the percentile value of the <i>F</i> -distribution at the 5% significance level.	97
52. Average gain scores for each question on a form. Values connected by the same line are not significantly different at the 5% significance level.	97

CHAPTER I

INTRODUCTION

It is estimated that 13 workers die each day and another 11,000 require lost work days or restricted activity due to serious injuries (General Accounting Office, 1992a). Such injuries can occur when workers are unfamiliar with exposures and reactions associated with chemicals used as a part of their job (Ashford, 1977). The General Accounting Office estimated the cost of these injuries and deaths, excluding occupational illnesses, to be about 83 billion dollars in 1989 alone (GAO, 1992a). These costs are the result of medical expenses, lost time wages, insurance claims, and other costs to industries nationwide. Less quantifiable but also considered important was the pain, suffering, and inconvenience experienced by workers and their families as a result of these occurrences.

As stated in the general duty clause of the Occupational Safety and Health (OSH) Act 1970, "It's the employers' responsibility to provide and assure safe and healthful working conditions for employees (OSHA, 1991a)." During the time period of 1983-1987 the OSH Act was amended to include the Hazard Communication Standard (HCS), 29 CFR 1910.1200, which required all employers to identify workplace chemical hazards and educate employees in exposure preventive methods including use of protective equipment (OSHA, 1991b). A part of the Hazard Communication Standard, thought by many to be

the foundation of hazard communication, is the Material Safety Data Sheet (MSDS). The Material Safety Data Sheet recommended by HCS is an eight-part document that provides descriptive data to inform employees about the chemical characteristics, hazardous properties, health effects, and precautions necessary to safely use a product or chemical compound. The Hazard Communication Standard further requires training of employees in methods of protection against such hazards. Training methods utilized by industries may be extensive, as found in larger corporations, or entirely nonexistent as found in many small scale industries which may use fewer chemical compounds and have fewer resources (Ashford, 1985). Eighty percent of small employers who reportedly comply with the Occupational Safety and Health Administration (OSHA) had reported problems in meeting the Hazard Communication Standard requirement for training (General Accounting Office, 1992b). Larger industries are even more likely to have some problems in compliance with all aspects of the HCS training requirements (Figure 1). Specific problems were insufficient training expertise and that MSDSs were too complex (GAO, 1992b).

Employees of industry must be given access to the Material Safety Data Sheet (MSDS) in accordance with the HCS. However, such sheets without professional interpretation may be too technical or complex for even a highly educated worker to understand as stated by the following university employee (Nelkin and Brown, 1984):

The chemical safety data sheets are very vague and any employee who's going to assume his rights under the Right to Know law needs professional assistance. A competent chemist or

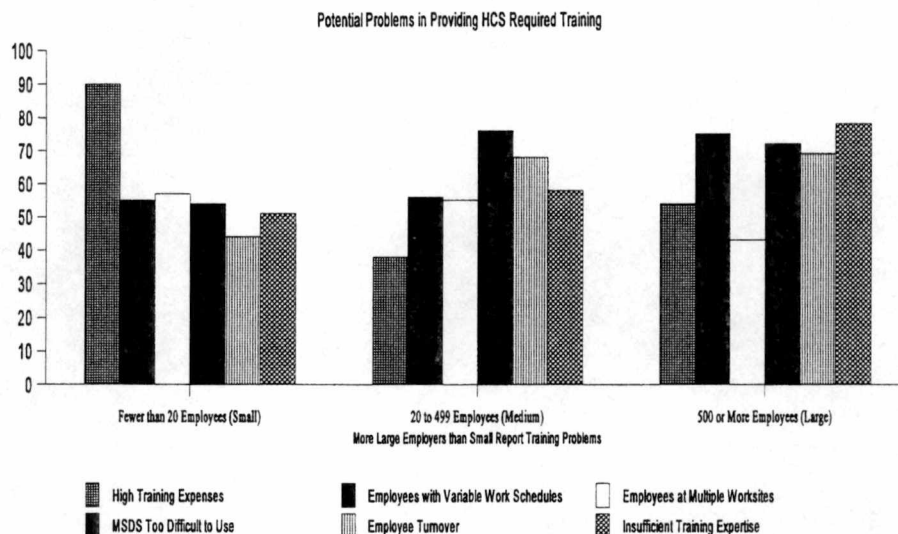


Figure 1. Employers' experience in complying with Hazard Communication Standard training requirements. From Employers' Experience in Complying with the Hazard Communication Standard, GAO, 1992b.

environmental hygienist should sit down with him and explain the terms. I have a college education and I needed help understanding and identifying these things. Either it has to be put in language that people understand or there has to be more professional assistance.

Ten years later a Kansas City wholesale distributor expressed the following similar feelings (Meninger and Margolies, 1994):

Most of the information contained (in MSDSs) is so esoteric as to be understood only by professionals trained in chemistry or toxicology. Consequently, there is not much impetus for the worker to retain the little information that can be comprehended, no matter how much information the employer provides.

A study of 100 union workers in several manufacturing facilities in Maryland revealed that a third of the crucial health and safety information on the

Material Safety Data Sheet was incomprehensible (Kolp, Sattler, Blaynew, and Sherwood, 1993). The study also revealed that the readability of the MSDS, worker literacy, and reading grade levels were key factors in lack of comprehension of the MSDS (Kolp et al., 1993.)

Many employers simply provide the MSDS to employees with instructions to read prior to working with specific chemicals (Samways, 1988). Some employers such as Lockheed Martin Energy Systems, Inc. (Energy Systems) and Lockheed Martin Energy Research Corporation, Oak Ridge, Tennessee, provide communication of risks associated with hazardous materials to employees by computer. The Energy Systems approach has been one not only of providing a computerized MSDS system to its employees, but also providing easy access to the information which is continually updated by trained personnel. This interactive system which is the primary communication tool on chemical hazards also provides subsets of information in paper form to employee groups that either could not or did not want to access information electronically (Ensminger, Lu, and Oen, 1988).

Statement of Problem

Difficulty in interpretation and use of the MSDS has often been reported in the literature (Meninger and Margolies, 1994). There is an assumption by employers in numerous instances that simply providing the MSDS to employees will enable them to understand all that is necessary to protect themselves and

will meet Occupational Safety and Health Act requirements. Others believe, as indicated by current formats in use, that the more information provided on the MSDS form, the better for the employee and employer (Samways, 1988). Either assumption could result in misunderstanding of content by workers that could lead to injury or death associated with unnecessary exposure to toxic chemicals and their reactions. This study was designed to evaluate three MSDS formats as to ease of understanding, their ability to diffuse health and safety information to workers, and worker acceptability of MSDSs. Also a comparison between an OSHA type form, Chemical Manufacturer Association/American National Standards Institute (CMA/ANSI Z400.1) form, and the International Chemical Safety Card (ICSC) for any significant differences in efficacy was conducted.

Purpose of the Study

The purpose of the study is to determine how well the Material Safety Data Sheet diffuses information to workers; compare the efficacy of an OSHA type form with the CMA/ANSI Z400.1 format and the International Chemical Safety Card; and determine acceptability and understandability to workers studied.

Hypotheses

To achieve the purpose of providing a clearly defined study on the efficacy of Material Safety Data Sheets, information was sought about five areas: (1)

effect of MSDS format on efficacy, (2) age effect, (3) education level effect, (4) years of work effect, and (5) number of chemicals worked with effect. Therefore, the following null hypotheses were tested for significance at the .05 level.

- H₀₁ The use of an OSHA type form MSDS as a reference does not significantly provide the worker with safety and health information.
- H₀₂ The use of the CMA/ANSI Z400.1 MSDS form as a reference does not significantly provide the worker with safety and health information.
- H₀₃ The use of the ICSC form as a reference does not significantly provide the worker with the safety and health information.
- H₀₄ There is no significant difference between the OSHA type form, CMA/ANSI Z400.1, and ICSC MSDS's as references to the worker on safety and health information.
- H₀₅ There is no significant difference between the OSHA type form, CMA/ANSI Z400.1, ICSC form, and the control group.
- H₀₆ There is no significant difference in the average test scores achieved on the OSHA type form, CMA/ANSI Z400.1, and ICSC forms between groupings on number of chemicals used.
- H₀₇ There is no significant difference in the average test scores achieved on the OSHA type form, CMA/ANSI Z400.1, and ICSC forms between groupings of grade level completed.
- H₀₈ There is no significant difference in the average test scores achieved on the OSHA type form, CMA/ANSI Z400.1, and ICSC forms between groupings on years worked at the national laboratory.

H₀₉ There is no significant difference in the average test scores achieved on The OSHA type form, CMA/ANSI Z400.1, and ICSC forms between groupings on age.

H₀₁₀ There is no significant difference in the average gain scores achieved on each question of the MSDS comprehensibility test between the OSHA type form, CMA/ANSI Z400.1, and the ICSC format.

To further enhance this study, the following research questions on efficacy and acceptability of the MSDS to union workers studied were asked:

- Q1 What was the general profile of union workers sampled that would utilize MSDSs at the national laboratory?
- Q2 What was the level of training on MSDSs and, as a result, what impact, as measured by ability to select appropriate time to use, was experienced by the workers inventoried?
- Q3 What was the level of understanding of MSDSs as indicated through difficulty experienced with words readability, format, and symbols?
- Q4 What was the level of accessibility of MSDSs to workers as indicated by availability/response to requests and method of responses?
- Q5 What was the level of acceptability of MSDSs to workers as indicated through satisfaction with information provided, frequency of use, and altered work habits?
- Q6 What beliefs were held by union workers as to the risk or threat associated with chemical usage?

Need for the Study

No matter in what format the MSDS is provided to workers, the ability to understand its content or message is of singular importance in protecting health and safety. Considering this goal, it is necessary to explore the current interface between workers, MSDSs, and resultant understanding. Only a few published studies defining user friendliness and understanding of the MSDS in relation to the average worker exist. The extensively used OSHA type format and the recently released CMA/ANSI Z400.1 MSDS have had a paucity of testing on the ability of each in disseminating information to the worker (Hans, 1994). Evaluations that have been made were mostly descriptive in nature.

The need for this study was underscored by the large numbers of deaths, injuries, and illnesses which occur in U.S. industries every year. Over 482,000 occupational illnesses were diagnosed in 1993 and 24,000 respiratory illnesses due to toxic agent exposure (National Safety Council [NSC], 1995). Of primary concern in reducing exposures was employee understanding of protective information included in the MSDS.

The complexity of the MSDS varies with the numerous different formats that are part of the approximate four billion in circulation in the United States (Van Santen, 1989). The Chemical Manufacturers Association (CMA), which has over 200,000 chemical products in its computer system, in concert with the American National Standards Institute(ANSI), adopted a uniform MSDS format which was released as a voluntary consensus standard early in 1993. User

friendliness of this format, which was expanded to sixteen sections, and the OSHA type form need to be further evaluated and compared in the worker population. The standardized CMA/ANSI format, also referred to as structure, was established to provide consistency in lieu of the numerous different formats allowed under the OSHA performance based standard favored by industry (Campbell, 1992). This new MSDS adopted by CMA and several European countries could cost hundreds of millions of dollars to implement (Van Santen, 1989 and Campbell, 1992). Such a large outlay of resources needs to be justified through strong supportive research evidence that format is a significant problem associated with user understanding of the current OSHA Form 174 and its hybrids.

Further, the Hazard Communication Standard (HCS), which includes the MSDS requirement, has been cited by employers as having no significant impact on the reduction of workplace related injuries and illnesses (GAO, 1992a). If a majority of employers believe this to be true (82-84 percent) the inability of workers in deciphering the MSDS could be a contributing factor. Employer difficulty in providing adequate training on the MSDS could also contribute to this opinion. The efficacy of the MSDS in diffusion of health and safety information to the workers needs to be explored. The HCS, 29 CFR 1910.1200, requires that all employees be made aware of health hazards associated with chemicals with which they work. The MSDS is an information source required to be used to inform the employee in this process (Occupational Safety and Health Administration [OSHA], 1991b). How well employees understand and accept

this document could drastically affect their health and safety and the safety of others.

Delimitations

This study was delimited to hourly wage plant and equipment division union workers of the Atomic Trades and Labor Council (ATLC) at a large national research laboratory located in Oak Ridge, Tennessee. The study involved only hourly employees, excluding weekly, salaried, contract employees, and visiting researchers.

Limitations

The major limitations of the study were:

1. The conduct of the research was dependent on the willingness of a designated number of employees to voluntarily participate in the evaluation of the efficacy and understandability of the MSDS's.
2. Sample size was dependent on availability of funding necessary to pay for the worker's time while undergoing the study.
3. The research was conducted during a period of downsizing at the laboratory.
4. Some employees may not complete the inventory questionnaire and pretests and posttests.
5. Since the sample selection was purposive in nature the results may not be

generalizable to all ORNL employees who utilize the MSDS.

6. All testing was conducted during a one-hour time period.

Assumptions

1. The employees studied are relatively similar in their knowledge about the Hazard Communication Standard and MSDS usage.
2. The technique of evaluation and testing are appropriate to quantify and interpret the level of understanding of MSDS formats tested.
3. The effort and responses by workers to the testing methodology are honest and accurate.
4. The employees studied can read at the ninth grade level or higher.

Definition of Terms

See Appendix A.

Summary

Only a few studies have been conducted to evaluate how well the MSDS diffuses health and safety protection information to workers. These studies for the most part have been descriptive in nature. The most widely used form, the OSHA 174, is rapidly being replaced by the CMA/ANSI Z400.1 MSDS form. This replacement in part has been stimulated by the few qualitative studies conducted to date. It is the purpose of this study to compare the efficacy of an OSHA type

format, CMA/ANSI Z400.1 form, and International Chemical Safety Card (ICSC); evaluate the worker's ability to understand necessary information sufficient to protect themselves; and determine the form's acceptability to the worker. Based on the findings of the research appropriate recommendations for improving the MSDS will be provided if necessary.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The Material Safety Data Sheet (MSDS) is one of six basic chemical hazard information elements required to inform employers and employees in accordance with the provisions of the Hazard Communication Standard (HCS) of the Occupational Safety and Health Act (OSHACT 29 CFR 1910.1200). The Hazard Communication Standard adopted by the Occupational Safety and Health Administration in November 1983, required employers to provide their employees information about hazardous chemicals in the workplace (OSHA, 1991b). A written program, hazard evaluations, MSDSs, labels/signs, employee training, and information on measures to reduce exposures and handle emergency situations were required under this law (29 CFR 1910.1200). Assumptions were made by lawmakers that, by informing workers of key information about the hazards with which they worked, harm and injury could be significantly reduced (OSHA, 1991b). This type of result has not been demonstrated (GAO, 1992b). To the contrary, the General Accounting Office, in a survey in 1992, found that no significant impact has been made on illness and injury rates from the issuance of the MSDS (GAO, 1992a). During 1983-87 mine, construction, transportation, and farm industries in total averaged 84.5 occupational related deaths per 100,000 full time workers. With the addition of

nursing and personal care workers, this same group averaged 56.6 injuries per 100 full time workers (Department of Health and Human Services [DHHS], 1991). In the manufacturing and meat product worker's industries, there were 4275 cumulative trauma disorders per 100,000 workers during 1987 alone (DHHS, 1991). There were 6200 cases of Hepatitis-B infections in occupationally related personnel reported in 1987. All of these preceding levels were targeted to be reduced as part of DHHS, national health objectives by the year 2000 (DHHS, 1991).

Chemical manufacturers and importers under the HCS must evaluate chemicals they produce or import to see if they would be hazardous when used in the work place (OSHA, 1991b). The MSDS and labels must be developed for those chemicals considered hazardous and both must be provided to receiving employers (29 CFR 1910.1200). Employers are required to maintain a file of MSDSs which must be readily accessible to employees at the work site and employees must be trained in the safe handling and use of all hazardous chemicals (OSHA, 1991b). A recent survey found small industries and all employers to be 58 percent and 52 percent, respectively, out of compliance with these key elements of the HCS (GAO, 1992b). Compliance assumed that an MSDS file, training of employees, and labeling containers had been met. These three elements are HCS requirements (29 CFR 1910.1200).

The Material Safety Data Sheet (MSDS) is the central requirement of the HCS in that labeling and training content require its presence. The MSDS has come under repeated attack for its length and difficulty in understanding,

especially by the user employee who may be illiterate or have poor reading ability and no exposure to chemistry (Tompkins, 1991). The MSDS format and language have been cited as weaknesses (GAO, 1992b). The purpose of this literature review will be to examine the history of development, format, content, proposed future use, and published studies conducted on the MSDS.

History of Hazard Information Development

The Material Safety Data Sheet and content requirements resulted through centuries of human experiences and experimentation with the elements, physical forces, the search for food, and the practice in alchemy (Kaplan, 1986). Earliest humans undoubtedly learned the hazards associated with fire, wind, rain, wild animals, and toxic foods, which were passed on to future generations verbally or through cave wall drawings (Kaplan, 1986). The earliest written evidence of an understanding of hazards associated with chemical substances or medicines were reflected in hieroglyphics on the walls of Egyptian tombs and in Papyrus scrolls over 4000 years old (Kaplan, 1986 and Molinelli, Reale and Freudenthal, 1992). The Samaritans, Greeks, Romans, and early medieval alchemists all played roles in the assimilation of chemical data throughout early history (Darrow, 1928 and Kaplan, 1986). Most notably the contribution of Islamic Nations during the Dark Ages of Europe, centered out of Baghdad and Alexandria, added to the knowledge passed on by the Greeks and Romans (Singer, 1959). They also contributed formulations and information received from China, India, and the Far East (Singer, 1959). According to Kaplan (1986),

this information migrated northward to Europe via Italy and France at the end of the 14th Century and helped in stimulating the Great European Awakening (Renaissance). Development of the ability to mass print in the 15th Century and a couple of centuries later the adoption of standard units of measurements greatly enhanced the ability to disseminate hazardous chemical information (Darrow, 1928, and Kaplan, 1986).

From the middle of the 19th Century forward, chemical producers began supplying customers with rudimentary hazard warning data sheets which according to Kaplan probably met the requirements of Sections I, III, and IV of the MSDS which includes manufacturers' pertinent information, chemical name, formula, physical data, and special precautions (Kaplan, 1986). As early as 1906, a company by the name of Valentine Chemicals, was producing an early example of an MSDS. From the 17th Century forward to the 20th Century, encouraged by insurance companies and fire protection groups and as a result of the advancement in toxicology research in Europe and the United States, the major chemical reactivity and toxicological data to be reflected in Section IV-VI of the MSDS were developed (Kaplan, 1986). Further added in 1938 by the National Conference of Governmental Industrial Hygienists were the Maximum Allowable Concentrations (MACs) later to become Threshold Limit Values (TLVs) in 1958-59. OSHA Permissible Exposure Limits (PELs) Time Weighted Averages (TWAs) were derived from the TLVs created by the American Conference of Governmental Industrial Hygienists (ACGIH), the successor organization to the 1938 group (Kaplan, 1986). Emergency and first aid

response, Section VII, was provided with information from the Chemical Manufacturers' Association (CMA), United States Department of Transportation (DOT), insurance companies, and the National Fire Protection Association (NFPA). Section VIII and IX entitled, "Special Protection Information," and "Hazardous Ingredients," respectively, made up the remainder sections of the original OSHA Form-20, the recommended minimal MSDS format (OSHA, 1991b, and Kaplan, 1986). Both of these sections were of recent development in response to special protection requirements and special industry needs.

Kaplan (1986) reported that various forms of chemical information sheets were published from 1945 through 1951; the "Controlling Chemical Hazard Series," by the Department of Labor; CMA's, "Chemical Safety Data Sheets," and the American Association of Casualty and Safety Company published a series of "Special Hazard Bulletins," and "Chemical Hazard Bulletins." The first MSDS Form No. LSB-005-4, a precursor to the OSHA Form-20, was incorporated into the Maritime Safety Act (August 23, 1968) in 33 FR 12008 as amendment to 29 CFR 1501, 1502, and 1503 (National Institute for Occupational Safety and Health [NIOSH], 1974). This same form became part of the Maritime Regulations, incorporated into OSHA. As a result of NIOSH's recommendations (NIOSH, 1974) and passage of the Hazard Communication Standard, 29 CFR 1910.1200, November 1985, all manufacturers and importers of chemicals were required to use OSHA Form-20 or equivalent (OSHA, 1991b). This requirement extended to all employers using chemicals, effective May 1986 (OSHA, 1991b).

Material Safety Data Sheet

Material Safety Data Sheets are documents that inform users about the chemical characteristics, hazardous properties, and precautions necessary to safely use and handle a product or chemical compounds (OSHA, 1991b, and Genium, 1992). The original OSHA Form-20 initially had nine sections (Figure 2) (OSHA, 1976). Section I was composed of the manufacturer's name and address, emergency telephone number, chemical compound name, and synonyms, trade names and synonyms, chemical family, and formula. Section II listed the hazardous ingredients subdivided into paints, preservatives, solvents, alloys, and metallica coatings with percentages and TLVs. Further added in this section were hazardous mixtures of other liquids, solids or gases with respective percentages and TLVs. Section III listed physical data such as the boiling point, vapor pressure, density, solubility in water, and evaporation rate. Section IV of OSHA Form-20 included fire and explosion hazard data (lower explosion limits and upper explosion limits) and unusual fire and explosion hazards. Section V described pertinent health hazard data such as TLVs, effects of over exposure, and emergency and first aid procedures. Section VI listed reactivity data to include stability, conditions to avoid, incompatibilities, and hazardous polymerization data. Section VII informed the user about spill and leak procedures. Section VIII included special protection information such as respiratory protection equipment, ventilation, eye protection, and other special precautions. Finally, Section IX, special precautions, informed the user about

special actions to take during storing and handling of a chemical.

The above sections were originally required under 29 CFR Parts 1501, 1502, and 1503. Section 41 of the 1968, Longshoreman's and Harbor Workers Compensation Act, 33 US Code 941, was adopted by OSHA in April 1971 as 29 CFR Parts 1915, 1916, and 1917, respectively (NIOSH, 1974). The nine sections were required to be recorded on OSHA Form-20, "Material Safety Data Sheet," or equivalent form to be approved by OSHA (Figure 2).

In an early attempt to develop an HCS in 1975, NIOSH developed a "Recommended Standard for an Identification System for Occupationally Hazardous Materials," based on a system of placarding, labeling, and MSDSs. This system, a precursor to the HCS of 1983, was designed to identify hazardous materials, degree and type of hazard, signs and symptoms of overexposure, prescribed safe handling procedures, emergency care, and disposal methods (NIOSH, 1974). The standard for the first time included the recommendation that the MSDS be used for training. "The MSDS can be used as a training aid and basis for discussion during safety meetings and training of new employees" (NIOSH, 1974). In particular the standard cited deficiencies with existing systems of warning as follows: Food and Drug Administration labeling requirements; label warnings of the Federal Insecticide, Fungicide, and Rodenticide Act of 1970; Department of Transportation Hazard Identification System; the National Fire Protection Association (NFPA) recommended system for the identification of fire hazards of materials; and the CMA Labels and Precautionary Information System (LAPI). After about 15 years of use in 1986,

the OSHA Form-20 was replaced by the OSHA Form 174 with only minor changes in content (Figure 3).

An effort was put forth recently by OSHA (1990) to solicit input on developing a more comprehensive or improved version of the MSDS in hopes of improving the quality and presentation of the current OSHA Form 174 or private industry approved equivalent (Long, 1992, and Vartarian, 1990). A new area of information that was considered for addition to the MSDS was information not required under OSHA (Long, 1992). EPA required data, SARA Title III information requirements and Community Right to Know information needs may be included in the future (West, 1991a, and Hadden, 1988). The CMA in concert with OSHA and the American National Standards Institute (ANSI), recently released a new version of what may be the future MSDS (Figure 4). It has been formatted differently and expanded to 16 sections (Hans, 1994). Supposedly, the new version was more user friendly, increases the amount of data on the form, and allows reformatting to accommodate information and presentation needs.

The new CMA/ANSI MSDS resulted out of confusion in the industrial field brought about by the performance oriented approach allowed by OSHA for industries creating MSDSs (Actvator, 1990, and Long, 1992). Often industries would conflict as to what was called hazardous and lengths of the MSDS varied from two pages to many pages (West, 1991a). The OSHA form, initially created primarily for industrial hygiene and safety professional use in educating the work force, was soon complicated by having to serve the needs of other groups such

Figure 3. OSHA Form 174 from the Occupational Safety and Health Administration “Material Safety Data Sheet.” Department of Labor, 1985, Washington, D.C., U.S. Government Printing Office.

THE CMA/ANSI MSDS RULE GIVE LOGIC CONSISTENCY TO STRUCTURE	
The standard being developed by the Chemical Manufacturers Association for certification by the American National Standards Institute provides a logical and internally consistent structure for Material Safety Data Sheets (MSDSs). If the standard is followed, users of the data sheets will always be able to find the information they need in the same place on every sheet. The structure is determined by a sequence of four questions for which the MSDS provides answers.	
1. What is the material and what do I need to know immediately in an emergency? SECTION 1. Chemical Product and Company Identification • Links the MSDS to the material. • Identifies the supplier of the MSDS. • Identifies a source for more information, including emergency information, if available. SECTION 2. Composition and Information on Ingredients • Lists the Occupational Safety and Health Administration hazardous components. • May also list significant non-hazardous components. • Lists corresponding Chemical Abstracts Service Registry Numbers, where appropriate, for each component. • May include additional information, such as exposure guidelines about components. SECTION 3. Hazards Identification • Provides information on the potential adverse health effects and symptoms that might result from reasonably foreseeable use and misuse of the material. • May provide an emergency overview that describes the material's appearance and severe, immediate health, physical, and environmental hazards associated with emergency response situations.	2. What should I do if a hazardous situation occurs? SECTION 4. First-Aid Measures • Provides easily understandable instructions on what to do when results of exposure require immediate treatment and when simple measures may be taken before professional medical assistance is available. Instructions provide for each route of exposure. • May also include instructions to medial professionals. SECTION 5. Fire-Fighting Measures • Provides basic fire-fighting guidance, including appropriate extinguishing media. • Describes other fire and explosive properties useful for fighting fires involving the material such as flash points, explosive limits. SECTION 6. Accidental Release Measures • Describes actions to be taken to minimize the adverse effects of an accidental spill, leak, or release of the material.

Figure 4. Structure of CMA/ANSI MSDS from Long, J. R., "Standard for Material Safety Data Sheets in the Offing." Chemical and Engineering News, May 1992, 70, (20), pp. 7-11.

3. How can I prevent hazardous situations from occurring? SECTION 7. Handling and Storage • Provides information on appropriate practices for safe handling and storage of the material. SECTION 8. Exposure Controls-Personal Protection • Provides information on practices and/or equipment useful for minimizing worker exposure. • Provides guidance on personal protection equipment. • May also include exposure guidelines. SECTION 9. Physical and Chemical Properties • Identifies the physical and chemical properties that characterize the material. SECTION 10. Stability and Reactivity • Describes the conditions that could result in a potentially hazardous chemical reaction.	4. Is there any other useful information about this material? SECTION 11. Toxicological Information • May be used to provide information on toxicity testing of the material and/or its components for medical professionals, occupational safety and health professionals, and toxicologists. SECTION 12. Ecological Information • May be used to provide information on the effects the material may have on plants, animals, and its environmental fate. SECTION 13. Disposal Considerations • May provide information useful to determine appropriate disposal measures. SECTION 14. Transport Information • May provide basic shipping classification information SECTION 15. Regulatory Information • May be used to provide additional information on state, federal, and international regulations affecting the material or its components. SECTION 16. Other Information
---	--

Figure 4. Structure of CMA/ANSI MSDS (Continued).

as community members, emergency responders, fire fighters, employers of all industries, environmental professionals, and medical and legal professions to name a few (Campbell, 1992). The CMA/ANSI Standard considered the main two uses of the MSDS to be a training tool for workers and a resource for emergency responders (CMA/ANSI, 1992)

The CMA/ANSI consensus standard recommends a structure for a data sheet in lieu of just filling out a standardized form. In a recommended uniformity of organization that provides the first ten sections to meet United States requirements and the following six to meet international standards (Long, 1992), the sections are arranged in descending order of what users need to know. Four questions are asked with subsequent subsections to be added dependent on needs of the MSDS creator (Figure 4). The four questions asked are as follows: (1) What is the material and what do I need to know immediately in an emergency? (2) What should I do if a hazardous situation occurs? (3) How can I prevent hazardous situations from occurring? And (4) Is there any other useful information about this material (CMA/ANSI, 1992)? Preliminarily, the acceptance of the proposed form was met with mixed reviews ranging from comments of being too long and too expensive to adopt, to a state of excited acceptance (Long, 1992).

In an earlier attempt at MSDS simplification, Carriere (1985) proposed creating a quick visual observation chart from the MSDS for the trained chemical handlers use. The chart would cover the following five situations: the normal work environment, fire exposure, spills, incompatible storage requirements, and

emergency treatment. The chart would provide information for normal and emergency situations. The normal environment is one which the employee is exposed to on an average workday. The chart in a normal situation would address threshold limit values (TLVs), personal protective equipment (PPE), and exposure symptoms. In emergency situations information from the MSDS that addresses fires, spills, incompatible storage, and emergency treatment would also be listed on the chart. The chart could be specifically made based on each industry's requirements (Carrlere, 1985). No literature exists indicating wide acceptance or testing of this approach.

National MSDS Repository

In 1991, a joint Federal Government/Organization Resource Counselors (ORC) effort to develop an electronic system for transmitting, receiving, and accessing MSDSs was initiated (Mattheis, 1992). This task force grew out of increasing frustrations by industry and the federal government in handling paper MSDSs by the millions and as a result of increasing costs. This was an initial step toward a working National MSDS Repository. The elements of this repository according to Mattheis (1992), would include: electronic transmission to the repository by industries required to provide MSDSs under the HCS; a unique file associated with each company name; periodic file screening for updates; acceptance by OSHA in meeting HCS requirements of chemical producers to transmit MSDS with products; adoptions of a standardized MSDS such as the CMA/ANSI Z400.1; use of the ANSI Electronic Data Interchange

(EDI) X.12 by all involved; and OSHA oversight, funding, and operation of the repository (Craig, Featherstone, Frank, Klapper, and Rosen, 1995). The U.S. Navy has commissioned a prototype to study the feasibility of using this system as a vehicle for automated MSDS exchange between commercial customers and the government (Craig et al., 1995). This type of effort, although not fully operational or fully agreed upon at the time of this study, underscored the need to simplify the MSDS document and would require uniformity.

Hazard Information and Workers

In Brown's study (1984), three questions were asked about acquiring and using information concerning toxic substances in the workplace: (1) What influences worker's decisions to seek information? (2) How does information effect subsequent worker's actions? and (3) What barriers exist that limit worker's efforts to reduce risk? These questions identified information-seeking behavior among workers at risk. This study was timely in that it captured conditions in the workplace just prior to the HCS taking full effect and was the only such study found in literature describing hazard information needs of workers. A purposive study of qualitative design, it consisted of case studies on eight workers and interviews with eighty workers from various industries. The case studies explained experiences of eight singular individuals seeking information on a solution to work hazards at eight different industries in California (Nelkin and Brown, 1984). The interviews consisted of asking questions on workplace relations, hazards, personal health problems, company attitudes,

information seeking and use, and background perspectives on risk. The study concluded that workers sought information if they felt that conditions could be changed in the workplace. The findings indicated that even if a well organized active work rank and file existed, generally only specific hazards were resolved successfully. "The analysis of the study suggested that access to information alone would not necessarily result in a well-informed workforce" (Brown, 1984). As recognized in the 1991 GAO study and by Brown's (1984), distribution of hazard information or knowledge does not mean there will be a reduction of the incidence of disease and injuries in the workplace. It was suggested by Brown that a change in control over workplace decisions might be the key to reducing illnesses and injuries (Brown, 1984).

World Usage of MSDSs or Equivalent

The Canadian form of the MSDS is called the Workplace Hazardous Materials Information System (WHMIS) required by Canadian Federal Law, Bill 70, June 1987 (West, 1991b). Similar to the United States MSDS, but containing many significant differences, the WHMIS could be used in the United States. The reciprocal is not true in that the United States MSDS is not acceptable in Canada (West, 1991b). The difference with the WHMIS is that it requires: listing amounts of all ingredients; chemical abstract numbers (CAS); amounts and ranges of composition or ingredients; a strict format to be followed; new data every three years; proof of need for trade secret substantiation; and reissuance every three years (West, 1991b).

With the creation of the European Economic Community (EEC), a movement has begun to require preparation of MSDSs for all chemicals and mixtures (Campbell, 1992). Countries requiring MSDSs at the time of this study were Denmark, Finland, France, Germany, Norway, Sweden, Switzerland, and the United Kingdom. Only Finland had a required format. Some European countries had already adopted the draft CMA/ANSI MSDS (Campbell, 1992). Australia also had adopted a standardized MSDS (Van Santen, 1989, and Cumming, 1989). Worksafe Australia approved and agreed upon a national MSDS format with an explanatory guide in August 1989, after a 18-month effort by a tripartite Chemicals Standing Committee and a working party on MSDS (Bisby and Coles, 1988).

There was an ongoing effort toward creating a universal MSDS that meets the needs of countries requiring an MSDS to include language conversion (Molinelli et al., 1992, and Niemeier, 1996). The sixteen-section CMA/ANSI MSDS format was coordinated with major chemical associations of Canada, Europe, and Japan in reaching an agreement on section content and titles. All agreed on sections currently included in the CMA/ANSI document (Molinelli et al., 1992). In 1990, the General Conference of the International Labor Organization adopted Convention 170 and Recommendation 177 concerning safety in the use of chemicals at work and a classification scheme using the 16 sections of the CMA/ANSI format. The Commission of European communities in a June 5, 1991, Directive defined its safety data sheet format which included the same 16 section headings of the current CMA/ANSI MSDS document. The

European Community Directive made use of the document mandatory and it had to be available in local user languages. Although there is no formal agreement by all world nations to use a universal MSDS the actions taken so far by several of the world's largest trading groups and organizations may be leading to a universal MSDS (Molinelli et al., 1992). The necessity of such an effort is underscored by the difficulty of each country having unique and often dissimilar requirements for MSDSs.

Medical Community MSDS Needs

Of the six basic requirements of the Hazard Communication Standard (HCS), a written program, labeling, chemical inventory, generation and distribution of information on chemical hazards (MSDSs), labeling, and worker training, the requirement for an MSDS most directly effects the physician in patient care (OSHA, 1991b). Physicians may need to know toxicity information to conduct appropriate screening, biological monitoring, disease evaluation, and treatment of acute and subacute conditions related to job exposures (Lerman and Kipen, 1990). The physician needs to know exposures in the workplace to allow for preventive health care actions such as those required to protect pregnant workers and those with chronic conditions that can be exacerbated in the workplace. Physicians have the right to specific medical access to include trade secret information during an emergency (Emmet, 1988). During a nonemergency situation, the physician must sign a confidentiality statement (Emmet, 1988). Physicians often lack extensive toxicological training and must

access reference books, databases, and if available, experts such as occupational health physicians, industrial hygienists, and special government agencies (Himmelstein and Frumpkin, 1985). Some physicians feel that the MSDS serves merely as a starting point for further research on a patient's work exposure and should be augmented by a comprehensive literature review. Lerman and Kipen (1990) indicate that MSDSs often contain deficiencies that preclude a proficient physician from relying exclusively on them during evaluation of an exposed individual. One such noted deficiency was the lack of quantity of the dose a patient would have received during an exposure. In some cases, exposure measurements may become available under OSHA's Access to Medical and Exposure Records Rule, but collection of such information by the employer is not legally required for all chemicals (Himmelstein and Frumpkin, 1985). Material Safety Data Sheets are useful to the occupational health physician, occupational health nurse, and industrial hygienist by serving as the chemical identification document that allows for patient care, training, and appropriate protection, and monitoring in the workplace (Raniere, 1994, and Hathaway, 1978). Some nurses have set up toxicology charts based on information provided in the MSDS. Such a chart has the name, product name and commonly used name, physical characteristics of the substance, mode of entry into the body, long term and short term effects, physical assessment guidelines, first aid for an inadvertent exposure, long term care guidelines, engineering controls, and protective equipment necessary (Raniere, 1978). The chart is used to inform the medical staff about the workplace and workers about

chemical hazards and appropriate protective equipment. The gathering of the chart information allows for coordination of the occupation health team. Similar approaches of placing employee, work environment, and exposure together and placing them on databases with access by the physician, nurse, and industrial hygienist with integration of MSDS information have taken place throughout the United States (McNeely, 1990 and Ensminger et al., 1988).

Medical personnel, from the user viewpoint, also must be aware of ingredients and types of chemicals used in workplaces such as clinics, operating rooms, and hospitals (Stannevich, 1989 and Marousky, 1991). The HCS and the new Laboratory Standard (29 CFR 1910.1450) require that for every potentially hazardous chemical an MSDS be made available for employees in these locations (Marousky, 1991).

The industrial hygienist, a health professional who is trained in toxicology, physiology, chemistry, analytical, and preventive engineering techniques uses the MSDS for many purposes (Rom, 1983). The data sheet allows this health professional to identify components of a chemical associated with a work operation and provides information necessary to recognize hazards to workers that may exist (Solomon, 1988). The industrial hygienist will utilize, or review for correctness, information on the MSDS concerning health, control measures, hazard data, and personal protective equipment (Himmelstein and Frumpkin, 1985). The information will be utilized to train workers, advise on protective equipment or sampling procedure development (Hughs, 1991, Tan, et al., 1991, and Tompkins, 1991). The industrial hygienist bridges the gap between the

industrial area and medical personnel and, in doing so, uses the MSDS as a valued tool in this effort (Santodonato, 1981 and Rom, 1983).

Accuracy of the MSDS

In a descriptive study initiated by OSHA to evaluate the accuracy of the MSDS one hundred and fifty (150) randomly selected MSDSs were evaluated in 1991 (Kearney/Centaur, 1991a). Specifically studied were two indicators: correctness of information provided and completeness of information used in defining overall accuracy. Five areas of interest were tested against the above criteria: identification of hazardous ingredients, health effects, first aid, personal protective equipment, and exposure limits (Figure 4) (Kearney/Centaur, 1991a). This OSHA-funded study found that only 11% of the MSDSs studied had presented accurate information in the last four of the above categories important in protecting the worker (Kolp et al., 1995).

Respective accuracies for the five categories of interest were as follows: identification of hazardous ingredients, 83%; health effects, the most error prone category, 37%; first aid procedures, 76%; personal protective equipment, 47%; and exposure limits, 47% (Kearney/Centaur, 1991a). The three categories with lowest accuracy are critical in providing information necessary to protect the worker. It was noted by one reference source that it appeared as if accuracy were improving over time (Kolp et al., 1995). The more recent the MSDS the more accurate the data (Lu and Moure-Eraso, 1993). Accuracy and understanding of the MSDS are two necessary factors if an MSDS is to be

instrumental in assisting a worker to protect himself (Kearney/Centaur, 1991b, and Miller, 1986).

In a University of Massachusetts pilot study of six manufacturing companies a grading scale of (1)-(5) was used to evaluate the quality of information on Material Safety Data Sheets found in use (Lu and Moure-Eraso, 1993). Criteria for grading were (5) excellent; (4) good; (3) fair; (2) unsatisfactory and (1) poor. Excellent was awarded when all necessary information was provided on the MSDS and it was easy to read. The lower end of the scale poor (1) was awarded when little information was provided in information blocks (Lu and Moure-Eraso, 1993). The average grade was 2.24 (unsatisfactory) for MSDSs created prior to 1980 and 3.98 (fair to good) for MSDSs after 1990. The researcher attributed the increase in quality to the promulgation in 1984 of the Massachusetts "Right to Know Law," which required more encompassing MSDSs. The average grade for all MSDS's in the study was 3.27 (fair) indicating that additional information was needed (Lu and Moure-Eraso, 1993). The researcher utilized descriptive data from all plants surveyed, provided correlations between date of MSDS printing versus grade level and number of carcinogens in the plant versus grade level achieved by the MSDSs. Ease of readability, a subset of excellent, apparently was evaluated subjectively because no testing methodology was described. Method of MSDS selection and number was not explained by the researcher, weakening generalizability. The results of the data however will be utilized by the researcher as criterion to evaluate additional plants (Lu and Moure-Eraso, 1993).

Studies on Comprehensibility of the MSDS

Recently the Office of Program Evaluation (OSHA), US Department of Labor, Occupational Safety and Health Administration, under contract No. J-9-f-8-DO19, funded a descriptive study to determine the comprehensibility of the MSDS (Kearney/Centaur, 1991b). The Kearney/Centaur Division of A.T. Kearney, Inc. was awarded the contract study. Results of the study were submitted to OSHA in March of 1991. The reason for conducting the study was to determine whether workers understood the information provided on the MSDS sheet (Kearney/Centaur, 1991b). Particularly of interest was whether there was understanding by workers of routes of entry of toxic substances described in the MSDS, associated health hazards, protective measures, such as equipment or practices, and where to go for additional help (Kolp et al., 1993, and Kearney/Centaur, 1991b). This cross sectional study encompassed 100 MSDSs which were randomly selected from 10,000 located at the University of Maryland, Department of Environmental Safety file. Eighty percent were for specific chemical compounds, mixtures or elements and twenty percent for commercial products. The OSHA Form 174 was reflected in twenty-three percent of those MSDSs chosen, the remainder were industry OSHA type (Kearney/Centaur, 1991b).

The SMOG Test, recommended by the National Cancer Institute, to determine grade level readability was utilized by the researchers (Freimuth, 1979). The average readability of the 100 MSDSs used in the study was grade 12.03.

In 1990, one hundred unionized employees from 13 different manufacturing plants and a local union in Maryland, were tested on a voluntary basis for understanding of four types of MSDSs supplied each worker (Kearney/Centaur, 1991b). The four MSDSs supplied were chosen from the 100 randomly selected MSDSs mentioned above.

One of the four MSDSs used followed the OSHA 174 format; one not written in this style; one for a chemical common to each employee's workplace was supplied; and another for the same chemical from a different manufacturer than found used in the workplace evaluated. The readability of these MSDSs ranged from grade level 12 to 13, averaging about grade level 12. In one testing session of 18 workers a fifth version of a chemical safety data sheet, called the International Chemical Safety Card (ICSC), readability grade level 11, was evaluated for comprehensibility (Figure 5).

In evaluating worker's understanding of the four different MSDSs and ICSC, ten information areas found on each MSDS were read by workers who were tested for their understanding by a written questionnaire (Kolp et al., 1993, and Kearney/Centaur, 1991b). Also, demographic data were collected on plants where workers were employed and personal information about workers involved in the study which might serve as independent variables was collected, i.e., educational background (Kolp et al., 1993, and Kearney/Centaur, 1991b).

Results of the study involving 91 workers who eventually participated in the study revealed that on average about two-thirds of the information provided on the MSDS was understood by workers (Kolp et al., 1993). The average

comprehensibility of the OSHA 174 formatted MSDS was 60% and the ICSC form averaged six to twenty-three percent higher than the other four MSDSs tested. It was indicated that this result may mean a new format is warranted or was the result of the readability of the ICSC being grade level eleven (Kolp, et al., 1993). The test results indicated that workers better comprehend straightforward procedures and exhibit difficulty with complicated vocabulary, i.e., the term carcinogenicity (Kolp et al., 1993). Worker's characteristics played a role in test results with educational background having been the most important factor related to level of understanding (Kolp et al., 1993). A college education elevated test results by 8-12 points and with the average readability of the MSDSs being grade level twelve gave the advantage to the better educated (Kolp et al., 1993). Other factors that effected elevation in MSDS test scores were motivation in the past by employees to request information about chemicals used and prior experience with MSDSs. Workplace characteristics did not seem to effect test scores (Kolp et al., 1993).

The findings of the study revealed a need to ensure quality information on MSDSs, improve readability, create a better format and standardized glossary, and determine roles that labeling and safety training can play in improving understanding of the MSDS (Kolp et al., 1993). The major deficiency noted in the study was lack of use of appropriate statistical analysis methods to empower the inference of the findings.

In contrast a study conducted by the Printing Industry of America (PIA) performed on literacy levels among Master Printers and the readability of MSDSs

found that years of formal education do not significantly increase understandability of the MSDS (Kearney/Centaur, 1991b).

Employee Understanding of the MSDS

The MSDS in its OSHA type format with more than four billion in use in the United States, is not considered by many to be an easy document to read (Van Santen, 1989). Particularly for employees with limited reading ability or language skills or those foreign born or for whom English is not a native language, the MSDS is critically difficult to understand (Tompkins, 1991, and Cherniak, 1992). Approximately eighteen percent of the United States adult population is believed to be functionally illiterate and probably unfamiliar with technical terms used in the MSDS (Molinelli et al., 1992). Some employees have learning disabilities or do not read well, characterizing about one-fifth of the American workforce (Tompkins, 1991). Many employers are unaware of the illiteracy rate in their workplaces and employees for fear of losing jobs will not admit their inabilities (Ashford, 1985).

A value expectancy theory (Health Belief Model) and the Social Cognitive Theory (SCT) provide a theoretical explanation for the perceived difficulty in reading and understanding the MSDS (Rosenstock, Strecher, and Becker, 1988).

An even more subtle hurdle than comprehension by workers of the MSDS is the perception of risk that a worker may possess (Goldberg, Dar-EI, and Rubin, 1991). The Health Belief Model (HBM) suggests that health related

action depends on the simultaneous occurrence of three factors: (1) the presence of sufficient motivation (health concern) to make health issues important; (2) the perception that one is at risk (perceived threat); and (3) the belief that complying with health and safety recommendations will benefit the individual through lessening of the perceived threat at an acceptable cost in effort or financial outlays (Last and Rosenau, 1980, and Rosenstock, 1988).

Similar to the HBM the Social Cognitive Theory (SCT) involves expectancies about environmental cues which are analogous to the factor of perceived threat addressed in the HBM (Rosenstock et al., 1988). The SCT also includes expectations about outcomes, not dissimilar to the HBM perceived benefits from taking a particular health or safety action. Expectations about ones' ability to engage in or execute a behavior or action (self-efficacy) is involved in the HBM's perceived barriers or costs in carrying out a behavior (Rosenstock et al., 1988, and Glanz, Levis, and Rimer, 1990). Self-efficacy is a major contributor to the HBM and explains the importance of efficacy expectations in health and safety related behavior decisions (Strecher, Devellis, Becker, and Rosenstock, 1986). "Efficacy expectations are defined as the conviction that one can successfully execute the behavior that is required to produce outcomes," (Strecher et al., 1986). For example, if a worker perceives that the MSDS is difficult to read, this opinion may result from low self-efficacy in reading skills and scientific jargon. Further, for workers to wear personal protective equipment (behavior) for health protection (outcome), they must believe that such actions will be beneficial (outcome expectations) and that they

are capable of understanding the MSDS message (efficacy expectations) (Rosenstock et al., 1988). These two theories may explain worker difficulty with the MSDS; however, just as important, is the efficacy of the MSDS (change agent) in diffusing its message.

The Adoption Diffusion Innovation Theory explains that a message will be accepted or adopted more readily based on ease of understanding (Rogers, 1983). Diffusion is a process (linear model) by which messages are transferred from a source to a receiver (Rogers, 1983). Diffusion of innovations is a social or technological process in which subjectively perceived information about a new idea is communicated (Rogers, 1983). In the process of diffusion of information from the MSDS to the workers, the MSDS is the change agent imparting new ideas (innovations) to the receiver, the employee. The complexity of this information and its content is a limiting characteristic of innovations, one of five described as important in the adoption of a message (Rogers, 1983).

Failure to consider such theories as the Health Belief Model, Social Cognitive Theory, and Adoption Diffusion of Innovations in the relationships between the MSDS and worker could present obstacles to the understanding and acceptance of this health and safety protective document. In this literature review, no such actions on the part of MSDS creators were evident.

Considering the above, why continue to add additional data to an already overwhelmingly difficult document for workers to understand as noted by the following worker (Nelkin and Brown, 1984).

Somebody should take the data sheets that the manufacturers put out and explain them. The chemicals come into the plant with the original labels, mostly trade names. Unless you were a chemist or looked it up, you probably wouldn't know what it was. Most people don't know what the hell you're talking about with all these chemical terms. The bottom line is, "Do not inhale the vapors," so they will turn their head while they're sucking it in.

One recommended approach is to provide a summary MSDS that would inform workers in a more understandable manner. An example given by Hadden (1989) was an industry chemical fact sheet that would provide answers to the following questions in layman terminology: What is it? Where is it produced? How is it stored? What are the exposure limits? What are possible effects of excessive exposure to humans? How are workers protected from excessive exposure? What medical attention is needed for excessive exposure? and How is the product kept from entering the environment? The same type of approach could be used to meet community right to know requirements (Hance, 1988). Any additional information needs would be provided by the MSDS long form which the employee could provide his physician or someone more able to interpret its technical terms.

Summary

The literature review was intended to provide a synopsis of the development, use, and problems associated with the Material Safety Data Sheets. Particular attention was given to future developmental trends in structuring the new CMA/ANSI MSDS and movement toward development of a

universal MSDS. Emphasis was placed on the difficulty the user has in understanding the MSDS; theories that would assist in designing MSDSs; factors found by other studies effecting accuracy and understanding; and use requirements of other professional groups.

As revealed in the literature review, a small number of studies have been conducted over the past twenty years assessing the efficacy of the Material Safety Data Sheet (MSDS). These studies conducted by the Chemical Manufacturers Association (CMA), Nelkin and Brown, Lu and Moure-Eraso, Hadden, and Kolp, et al., were largely qualitative or descriptive in design and analyses. All of the studies did conclude that the MSDS format was hard to understand and needed improvement in formats, content, and readability. Some of the studies suggested a more simple form be designed while others advocated that more information and sections be added (Hans, 1994). Few solicited information from workers to support whether the MSDS was an acceptable and usable source of safety and health information. None of the aforementioned studies determined whether there was statistically significant diffusion of information from any MSDS or whether there is a significant difference in efficacy between different formats.

CHAPTER III

METHODOLOGY

Introduction

This study was designed to determine the acceptability of Material Safety Data Sheets; assess how well they diffuse information to workers; and provide a comparison of the efficacy of an OSHA type form, CMA/ANSI Z400.1 format, and the International Chemical Safety Card (ICSC). Approval was given by management to conduct the study at the Oak Ridge National Laboratory (Appendix B).

The methodology presented in this chapter includes selection of sample, instrumentation, treatments, research design, pilot study, data collection, data analysis, and summary.

Selection of Sample

A study was designed using a series of questionnaires to solicit information on MSDS acceptability and test workers' understanding of the MSDS as an indication of MSDS efficacy. Use of human subjects, exempt status, was approved by the Oak Ridge Associated Universities' Human Subjects Committee which approves research at the Oak Ridge National Laboratory (Appendix B).

Union workers consisting of hourly wage personnel, totaling 824 employees, at a national laboratory comprised the population studied. A

purposive sample of 160 of the workers randomly partitioned into four test groups of 40 participants was evaluated.

Historically the national laboratory, a government-owned contractor-operated facility, has had a stable work force providing conditions over the past 50 years conducive to hazard communication and training. The research conducted at the laboratory is of a nature requiring constant safety and health awareness. Similar conditions exist at other national laboratories located throughout the nation, which may allow for broad generalization of this study's findings to analogous workers at those facilities. The use of MSDSs has been a requirement for over thirteen years at the evaluated laboratory. Its workers were chosen for the study because of proximity, management and union provided resources and endorsement to recruit workers for the research effort.

Instrumentation

Two instruments were utilized to conduct this study. The first was an MSDS efficacy inventory written in forced response mode (Appendix C). The efficacy inventory included forty questions concerning the usefulness, comprehensibility, and acceptability of the MSDS to workers and questions of a demographic nature.

A panel consisting of a Certified Occupational Health Physician, five Industrial Hygienists trained in writing and reviewing MSDSs, and a union safety representative, reviewed the MSDS efficacy inventory for accuracy, reliability, and technical merit (Appendix D). Targeted for review by the panel to insure

inclusion in the inventory were areas of information considered necessary in identifying needs in the national laboratory MSDS program. As a result of panel review the inventory was designed to address worker demographic variables such as gender, age, education, time on the job, and worker classifications. Worker familiarity with the MSDS, training on its interpretation, and its availability were questions included in the inventory. Information on how the worker used the MSDS, its usefulness in explaining hazards, and how well it diffused information on worker protection and worker application was also requested. Important to this study were the inclusions in the inventory of questions on readability, understanding, and MSDS influence on worker's health protection behavior. Questions on health hazard ratings and workers' beliefs about chemical hazards were included. A few questions on usage of the MSDS from a similar study conducted by Kearney/Centaur in 1991 were also added.

The inventory was written at a ninth grade reading level and verified through SMOG testing (DHHS, 1992, and McLaughlin, 1969). The SMOG test is a readability test that simply predicts the approximate educational level a person must have in order to understand written materials (DHHS, 1992). This readability test has been found to be effective in adjusting reading levels for health related information documents by the National Cancer Institutes (DHHS, 1992).

In this study, to calculate the SMOG reading level, the entire written work (inventory) was used (DHHS, 1992). Ten consecutive sentences were counted off at the beginning, middle, and toward the end of the inventory (DHHS, 1992).

From the sample of 30 sentences, all words having three syllables or more were circled including repeated words (DHHS, 1992). The square root of the total number of polysyllabic words circled was determined (DHHS, 1992). This was done by finding its nearest perfect square and taking its square root (DHHS, 1992). As required by SMOG testing procedure, a constant of three was added to the square root derived (DHHS, 1992). The resultant number was the reading grade level a person must have reached if he or she were to fully understand the inventory text being read. In the case of this study all instruments and treatments were written or adjusted to the ninth grade reading level.

The second instrument consisted of a test that was used in the OSHA/Kearney Centaur study in 1991 and is used in this study with the permission of Kearney/Centaur, Division of A. T. Kearney Inc., the contractor for that study (Appendix E). The test will also be used for comparison of results between this study and the OSHA/Kearney/Centaur study. The test contains ten questions scored on a scale of ten points each with a total of one hundred points possible for complete knowledge about a chemical. A full range of knowledge of the following ten areas will be tested (Kearney/Centaur, 1991b):

- Routes of entry of the chemical substance into the worker's body;
- Acute health effects associated with the chemical;
- Body systems immediately affected by exposure;
- Cancer causing potential of the chemical;
- Body systems affected by a long term, multi-year exposure;
- Personal protection measures to be taken to avoid or protect

against the acute/chronic hazard;

- First aid procedures to follow;
- Fire avoidance and suppression procedures;
- Spill or leak containment and abatement procedures to follow; and
- Who to contact for more information.

These areas follow specifically those informational segments provided in the OSHA recommended MSDS format and were considered to be information workers need to know to protect themselves (Kearney/Centaur, 1991b). Use of the same test as the OSHA contracted Kearney/Centaur, 1991 study test, allowed the researcher to compare results of the different study designs. The test was SMOG tested revealing a ninth grade readability (DHHS, 1992 and Mclaughlin, 1969).

Two different MSDSs and the International Chemical Safety Card (ICSC) were utilized as the independent variables in the second part of the study involving a Randomized Control Group Pretest/Posttest design (Figure 6) (Appendix F). The ICSCs are not typical MSDSs, they are fact sheets prepared by the International Programme on Chemical Safety at the World Health Organization of the United Nations. They were developed for the use of international workers and for similar purposes of the MSDS. For the purpose of the study it was considered analogous to an MSDS. All three of these Material Safety Data Sheets were matched in readability at the ninth grade level utilizing the SMOG formula developed by Mclaughlin, 1969. Each treatment format included differed as follows: the OSHA type form consisted of nine sections, the

new CMA/ANSI form had 16 sections, and the ICSC had nine sections. All three forms were data sheets or fact sheets addressing the same chemical compound (methyl ethyl ketone). Two of the sheets were selected out of the national laboratory MSDS database consisting of over 23,000 MSDSs and the ICSC was added as similarly conducted in the Kearney/Centaur study, 1991. The two sheets selected from the laboratory were selected to match an OSHA type form and CMA/ANSI Z400.1 format so that comparisons could be made between these two forms.

Research Design

The research design used in the study (Figure 6) is similar to a Randomized Control Group Pretest/Posttest design (Campbell and Stanley, 1963, Design # 4). The design controls for many of the internal and external factors of invalidity.

Pilot Study

The MSDS usage inventory, pretest and posttest MSDS comprehensibility instruments, and study design were pilot tested against twenty voluntary workers at the national laboratory to evaluate readability, content, ease of understanding, and time required to complete the evaluation. A letter requesting workers to participate in the study and promising anonymity was administered prior to the evaluation (Appendix G).

Group I	R	O ₁	X ₁	O ₂
Group II	R	O ₁	X ₂	O ₂
Group III	R	O ₁	X ₃	O ₂
Group IV	R	O ₃		O ₄

R: Random assignment to groups I, II, III, and IV.
X₁: OSHA Type Form.
X₂: CMA/ANSI Z400.1 Form.
X₃: International Chemical Safety Card.
O₁: Pretest, O₁: Posttest, O₂: Pretest control, O₃: Posttest control, O₄

Figure 6. Randomized Control Group Pretest/Posttest Design adapted from Campbell, D. T., and Stanley, J. C. (1966). Experimental and Quasiexperimental Designs for Research. Chicago, IL; Rand McNally & Company.

The evaluation took one hour with the MSDS usage inventory being administered first, followed by the pretest, treatment and posttest, and employee comment. Worker comments were utilized to improve the MSDS usage inventory (Appendix H). Workers gain scores between the pretest and posttest were utilized to test analysis statistics. Although workers made comments on the pretest and posttest on comprehensibility of the MSDS, no changes were made to the instrument so that comparisons could be made between the final results of this study and the OSHA/Kearney/Centaur 1991 study (Appendix H).

Data Collection and Analysis

So that the test scores could be compared to the OSHA/Kearney/Centaur study (1991) the same scoring methods were utilized. Each of the nine questions or measures of knowledge (pretest) and diffused information (posttest) were given equal weight. Results from the tenth question on the MSDS comprehensibility test had to be deleted due to the unfair advantage it gave to the OSHA type form and CMA/ANSI formats. The ICSC form does not contain information that would answer question ten. A correct answer to any question was given a score of ten points and a totally incorrect answer was given zero points. Partially correct answers were given scores of between zero and ten points. A total score of ninety points for nine questions was possible. All question answers were scored against test question answer keys developed by a panel of Occupational Safety and Health experts (Appendix D). An answer key was developed for each MSDS form to be evaluated (Appendix I).

The MSDS efficacy inventory was administered to all four groups of forty workers prior to the pretest and posttest on MSDS comprehensibility. The forty question inventory was analyzed descriptively to determine the efficacy and acceptability of the MSDS to union workers studied. Statistics such as mean, median, mode, histograms, and chi-squares were utilized to analyze findings (Conover, 1971, and Huck, Comeir, and Bounds, 1974). In that the 160 union workers were purposively selected and not truly random only non-parametric statistics and descriptive methods were utilized for analysis of the inventory.

The union workers were randomly assigned to each of the four different test groups. This allowed for the use of parametric statistics in the analysis of this part of the study. As reflected in Figure 6, three different groups of forty union workers will receive a test questionnaire with ten questions before and after they have been given one of the different Material Safety Data Sheets. The second test will have the same questions randomized prior to its administration. The control group of forty individuals will only receive the test questionnaires. The average differences in the scores between questions for the pretest and posttest will be used as the response for each worker (Table 1). The response equates to the amount of information diffused to the worker as a result of using the MSDS. Sample size considerations are based on the following formula:

$$N = 2 (Z_{1-\alpha} + Z_{1-\beta})^2 \frac{\sigma^2}{\delta^2}$$

Where

$\underline{N}$ = the sample size for each treatment group ($\underline{N} = 40$),

$Z_{1-\alpha}$ = the $(1 - \alpha)$ percentile point of normal distribution,

α = false positive error or Type I error,

$Z_{1-\beta}$ = the $(1 - \beta)$ percentile point of the normal distribution,

β = the false negative error or Type II error,

σ^2 = the variance of the response (i.e., D_{avg}) for each group assumed to be the same for each group, and

δ^2 = the difference between the response means for the two groups.

Table 1. Average differences in scores between questions for pretest and posttest

Question	Test 1	Test 2	Difference
1	Q1,1	Q2,1	$D1=Q2,1 - Q1,1$
2	Q1,2	Q2,2	$D2=Q2,2 - Q1,2$
3	Q1,3	Q2,3	$D3=Q2,3 - Q1,3$
4	Q1,4	Q2,4	$D4=Q2,4 - Q1,4$
5	Q1,5	Q2,5	$D5=Q2,5 - Q1,5$
6	Q1,6	Q2,6	$D6=Q2,6 - Q1,6$
7	Q1,7	Q2,7	$D7=Q2,7 - Q1,7$
8	Q1,8	Q2,8	$D8=Q2,8 - Q1,8$
9	Q1,9	Q2,9	$D9=Q2,9 - Q1,9$
10*	Q1,10	Q2,10	$D10=Q2,10 - Q1,10$
Average	Q1,avg	Q2,avg	$D_{avg}=Q2,avg - Q1,avg$

* Question ten scores were not used in the computation of average gain scores.

For this research study, the false positive error or Type I error for a two-sided hypothesis test was selected as .05 of .025 in each tail (i.e., $z_{0.9975} = 1.960$). The false negative error or Type II error was examined for .01, .05, and .10 (i.e., $z_{0.99} = 2.326$, $z_{0.95} = 1.645$, and $z_{0.90} = 1.282$). Figure 7 plots the difference (δ) that can be detected for different values of the standard deviation (σ) of the response (i.e., D_{avg}) using the three values of the Type II error.

Figure 7 shows that if the response standard deviation = 10, the values for the difference between Test 1 and Test 2 which can be detected are 9.58, 8.06, and 7.25 for Type II errors of 1%, 5%, and 10%, respectively.

In comparing the response means the purpose of the experiment was to accept or reject the following null hypotheses about the three MSDSs tested:

1. The three treatments X_1 , X_2 , and X_3 did not significantly affect the posttest scores when compared to the pretests.
2. There is no significant difference demonstrated between the three treatments (X_1 , X_2 and X_3) effects.
3. If different, none of the treatments have the same effect.
4. There are no significant differences between each treatment and the control group.
5. There is no significant difference in the average gain scores achieved on each question of the MSDS comprehensibility test between the three different MSDS forms.
6. There is no significant difference in the average test scores achieved on the three different MSDS forms between groupings on age, grade level completed, years worked, and number of chemicals used.

The first question was answered through use of a one-tailed student t-test comparing the means of the pretest and posttests.

The second question was formulated by comparing the mean response of the three treatment groups using the method of analysis of variance (ANOVA) (Lothar, 1984). The analyses of variance statistical method determined the equality of the multiple treatment means. This method assumed that the treatment groups were independent, responses were appointed by a normal

distribution, and response variances of the treatment groups were equal.

A multiple comparison test was utilized to determine if there were differences among the means or which means differ from each other (Lothar, 1984). Failure to reject the hypothesis that two or more means are equal will not lead to a conclusion that the population means are equal. This conclusion was tested using a t-test. There is a problem however with repeated t-tests for all the possible pairs of means in this research study. If the Type I error = .05 for a single test, the overall error rate for multiple comparisons will be higher than .05. For example, a multiple comparison of three means represent three paired comparisons:

Two-Sided Test (Mean1 = Mean2)
Type I = 5%
Sample Size = 40 for each Group

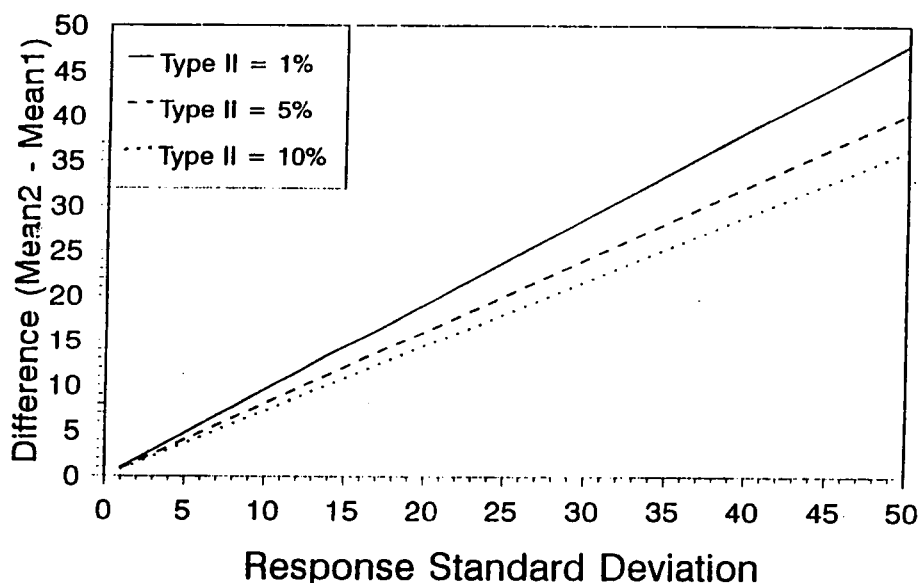


Figure 7. Type II errors for a two-sided hypothesis test of mean 1 = mean 2 at the 5% significance level with 40 samples from each population.

Mean 1 verses mean 2

Mean 1 verses mean 3

Mean 2 verses mean 3

The overall error rate for repeated t-test at the 5% significance level would be 14%. A multiple comparison method, the Sidak t-test, avoids this problem through adjusting the significance level to control for maximum experiment wise error (SAS, 1989). For equal sample sizes, as used in this study, the multiple comparison test of two means is:

$$| \text{Mean 1} - \text{Mean 2} | \geq t(\gamma, df) S \sqrt{2/n}$$

where

S = estimated response standard deviation,

N = sample size (e.g., N = 40),

t(γ , df) = (1- γ) - percentile value for the t-distribution with df = degrees of freedom (e.g., N = 40, 3 treatments df = 117).

The γ is adjusted for the following formula for an overall error rate of α for k comparisons:

$$\gamma = .5 [1 - (1 - \alpha)^{1/[k(k-1)/2]}]$$

For example, let Type I error rate α = .05 for k = 3 multiple comparisons with df = 117 then γ = 0.0170 and t(0.0170, 37) = 2.202.

A Dunnett's test (SAS, 1989) was used in the fifth null hypothesis where a multiple comparison test is a comparison with the control in this study:

$$| \text{Mean} - \text{Control} | \geq D(\alpha, df) S \sqrt{2/n}$$

where

$D(\alpha, df)$ = Dunnett's statistic for Type I error rate α and df = degrees of freedom,

S = pooled standard deviation estimated from the k comparison groups and the controlled group.

Summary

The research study consisted of a two-part analysis of 160 purposively selected union workers from a population of 824 union workers at a large national laboratory. The first part of the study applied an MSDS usage inventory to determine workers' usage, understanding, and acceptance of MSDSs. The second part of the study tested the ability of the MSDS to diffuse data to workers and compared three different MSDS type formats. As discussed, several different statistical treatments were utilized to support whether or not the Material Safety Data Sheet format played a significant role in ease of comprehension and acceptability to workers at a national laboratory.

CHAPTER IV

ANALYSIS OF DATA AND RESULTS

Introduction

The purposes of the study were to determine how well the Material Safety Data Sheet diffuses information to workers; to compare the efficacy of an OSHA type form with the CMA/ANSI Z400.1 and the International Chemical Safety Card (ICSC); and determine acceptability and understandability to workers studied.

Data were collected from a purposive sample of 160 hourly wage union workers of the Atomic Trades and Labor Council (ATLC), Oak Ridge, Tennessee, by administering an inventory questionnaire and MSDS comprehensibility tests to four groups of forty workers. The data collected were analyzed to discern the understandability and acceptability of the MSDS, and compare the efficacy of the MSDS in diffusing information to workers studied (Appendix J). While controlling for level of readability and chemical content, relationships between the variables of format, age, education, years worked, and the number of chemicals used were evaluated for effect on the efficacy of the MSDS. Additionally, information on training, difficulty in interpreting symbols, accessibility, satisfaction, altered work habits, and health beliefs were solicited to assess the acceptability of MSDSs to union workers studied.

Research Question One

What was the general profile of union workers sampled that would utilize MSDSs at the national laboratory?

Statistical Analysis System (SAS) computer programs were utilized for statistical analysis of data (SAS Institute, Inc., 1988). Union workers studied included 140 (87.5%) males and 20 (12.5%) females (Figure 8). The number of workers in various age groupings were 1 (0.6%) less than or equal to 29 years, 30 (18.8%) between 30-39, 80 (50%) between 40-49, 42 (26.3%) between 50-59, and 7 (4.4%) greater than or equal to 60 years of age (Figure 9). Workers reported educational level achieved in four ranges; 2 (1.3%) completed 5-8 years, 111 (69.4%) completed 9-12 years, 41 (25.6%) completed 13-15 years, and 6 (3.8%) completed 16 or greater years of education (Figure 10). Workers also responded that 79 (49.4%) had worked at the laboratory 0-10 years, 33 (20.6%) worked 11-20, 44 (27.5%) worked 21-30, and 4 (2.5%) greater than 30 years (Figure 11). Eighteen job categories were held by the union workers participating in the study shown in Table 2. Predominant job categories included carpenters, labor/pest controllers, and painters followed by pipefitters. When questioned as to the number of chemicals worked with on a weekly basis, 15 (9.4%) workers answered none, 118 (73.8%) indicated 1-5, 19 (11.9%) responded 6-10, and 8 (5.0%) worked with over ten chemicals (Figure 12). Sixty-seven (42%) of the workers studied indicated there were six to greater than ten MSDSs located in their workplaces with 59% less than five (Figure 13).

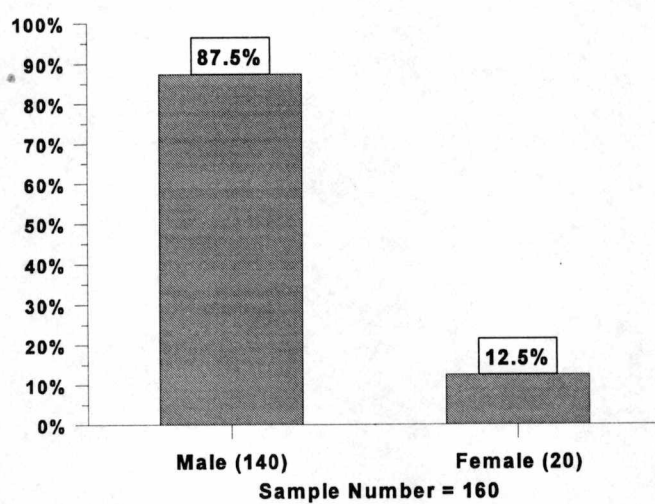


Figure 8. Question 1, gender?

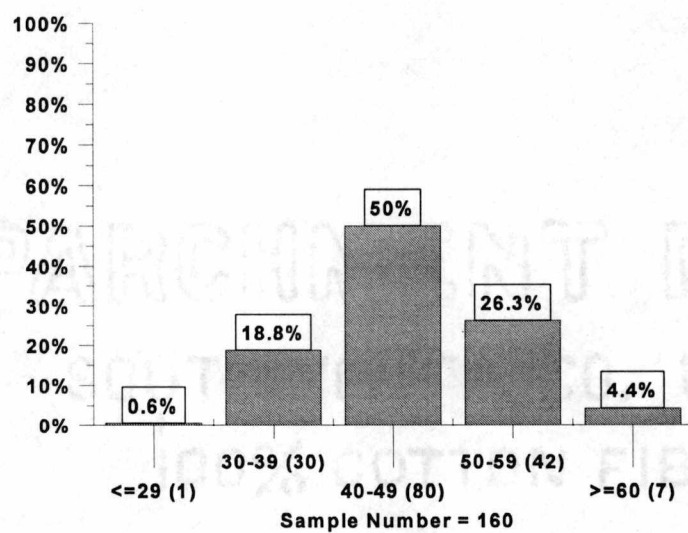


Figure 9. Question 2, what is your age group?

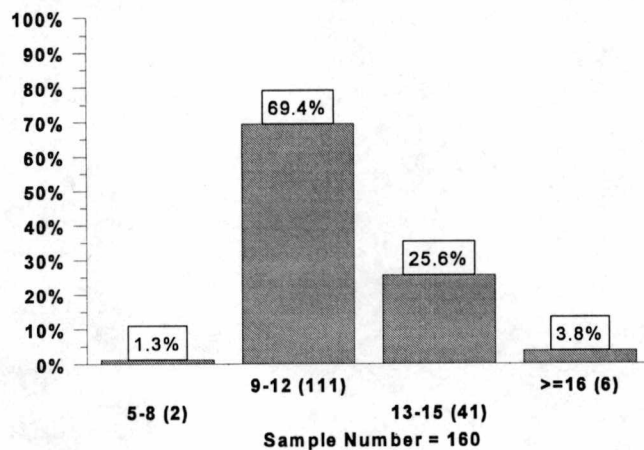


Figure 10. Question 3, indicate the highest grade level you completed in elementary school, high school or college.

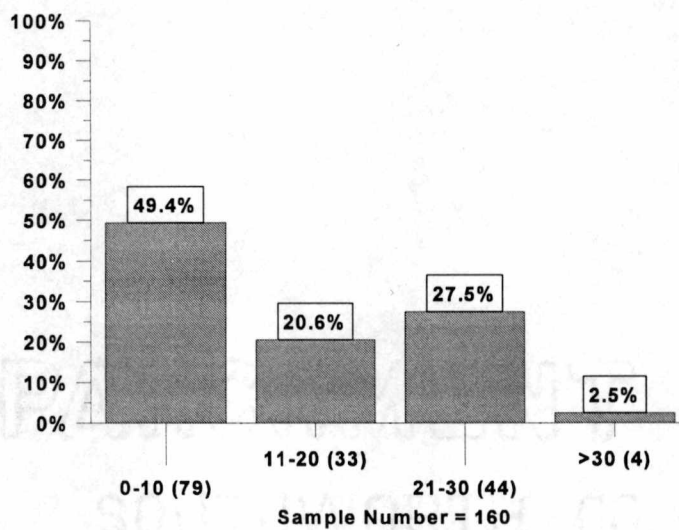


Figure 11. Question 4, how many years have you been working at ORNL?

Table 2. Job categories of sampled workers. (N = 160)

Job Category	Frequency	Percentage
A/C refrigeration	6	03.75
Boilermaker	4	02.5
Carpenter	21	13.13
Chemical worker	2	01.25
Electrician	10	06.25
Insulator	7	04.37
Laborer/Pest controller	21	13.13
Machinist	8	05.00
Millwright	9	05.63
Painter	21	13.13
Pipefitter	19	11.88
Power equipment operator	3	01.88
Rigger/iron worker	3	01.88
Sheetmetal worker	9	05.63
Steamplant worker	3	01.88
Truck driver	5	03.13
Utility mechanic	6	03.75
Welder	3	01.88

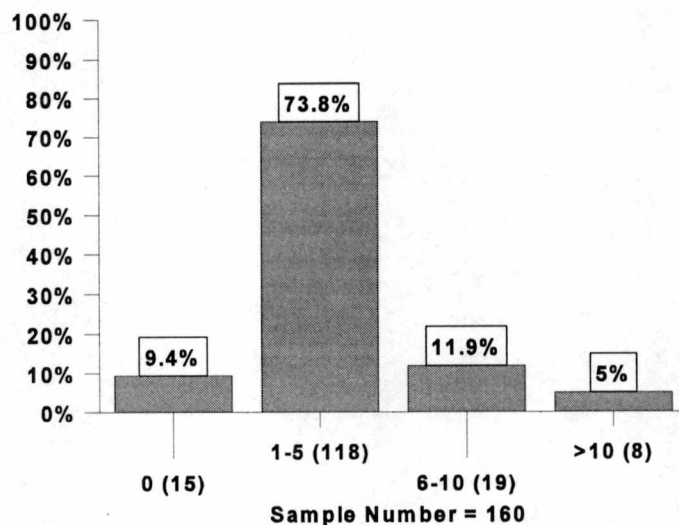


Figure 12. Question 7, how many chemicals do you use in your job on a weekly basis?

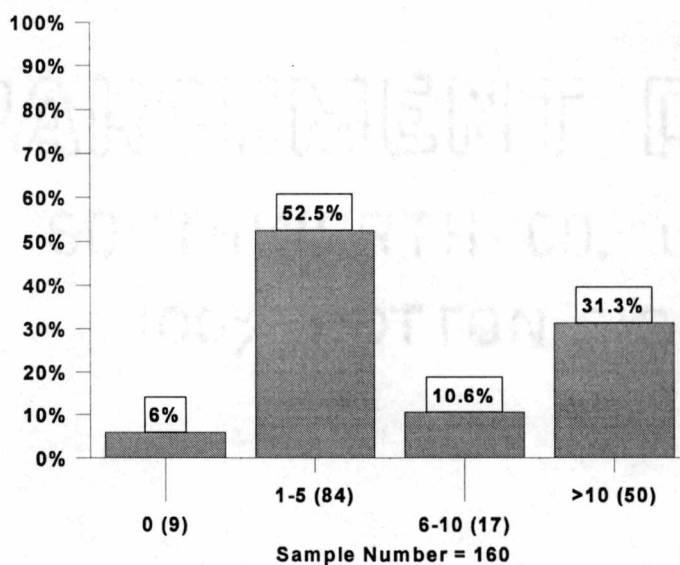


Figure 13. Question 9, I have seen the following number of MSDSs in my workplace.

Research Question Two

What was the level of training on MSDSs and as a result what impact, as measured by ability to select appropriate time to use, was experienced by the workers inventoried?

Ninety-four percent (150) of the workers studied had undergone some form of MSDS training either in the classroom, on the job or both (Figure 14). Six percent (10) had never received training. There seemed to be an agreement between the number of employees receiving training and their satisfaction with training at the national laboratory, $\chi^2 (6, N = 159) = 22.1, p < .05$. Eighty-five percent (136) of the workers responded that MSDS training provided at the national laboratory resulted in their understanding of work related hazards (Figure 15).

Seventy-six percent (125) of workers surveyed indicated they would like to be provided an MSDS during the planning stages of work, eleven percent (10) disagreed, while the remaining 14 percent (23) had no opinion (Figure 16). Seventy-nine percent (127) would like to see an MSDS during the job safety briefing with six percent (10) in disagreement (Figure 17). Eighty-eight percent (141) of the workers participating in the study would prefer to see an MSDS when first introduced to a new chemical with six percent (9) disagreeing (Figure 18). Fifty-seven percent (90) of the workers do not want to be given an MSDS after having worked with a chemical for sometime, while twenty-five percent (40) indicated they would like to be provided one (Figure 19). Thirty-eight percent

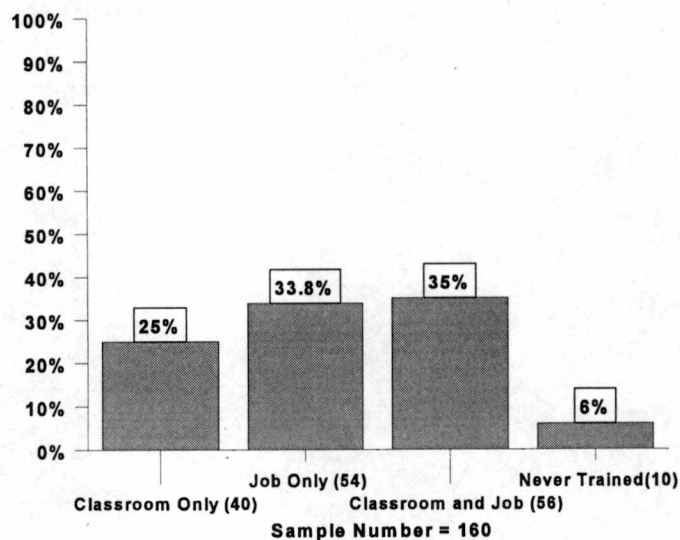


Figure 14. Question 8, I have received training on MSDSs.

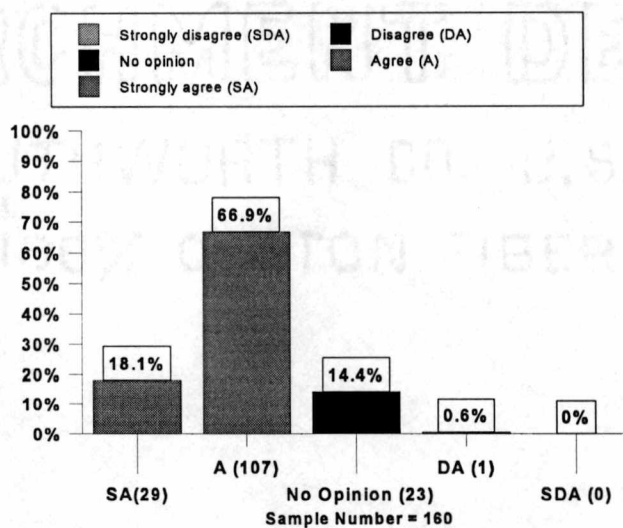


Figure 15. Question 12, to what extent do you think MSDS training provided to you was satisfactory in providing an understanding of the MSDS?

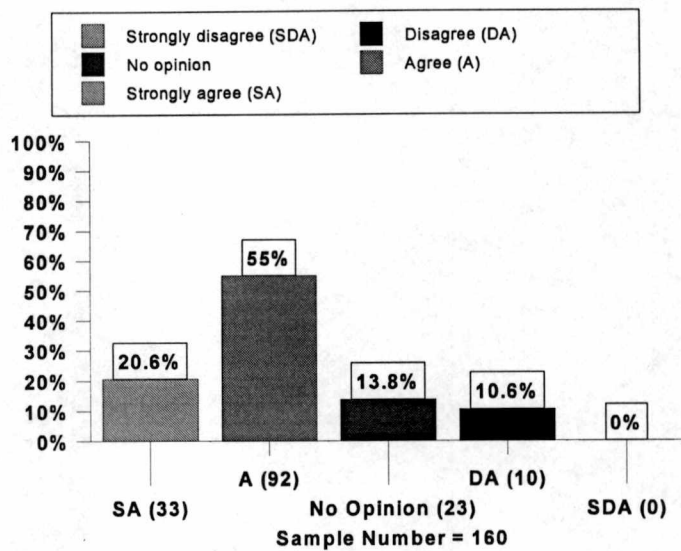


Figure 16. Question 23, I would like to see an MSDS during job planning.

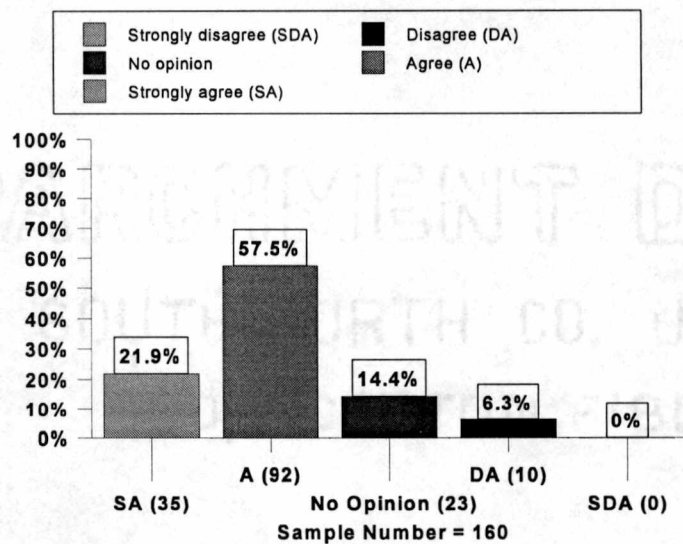


Figure 17. Question 24, I would like to see an MSDS during job safety briefing.

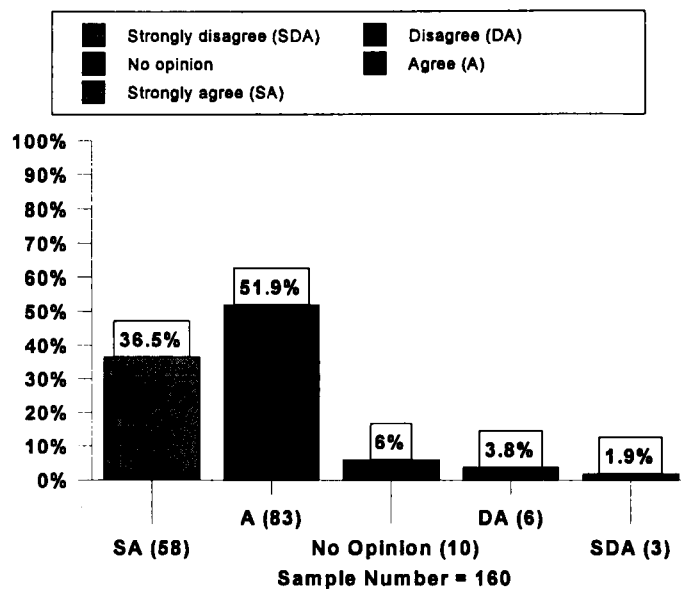


Figure 18. Question 26, I would ask to see an MSDS when first introduced to the chemical.

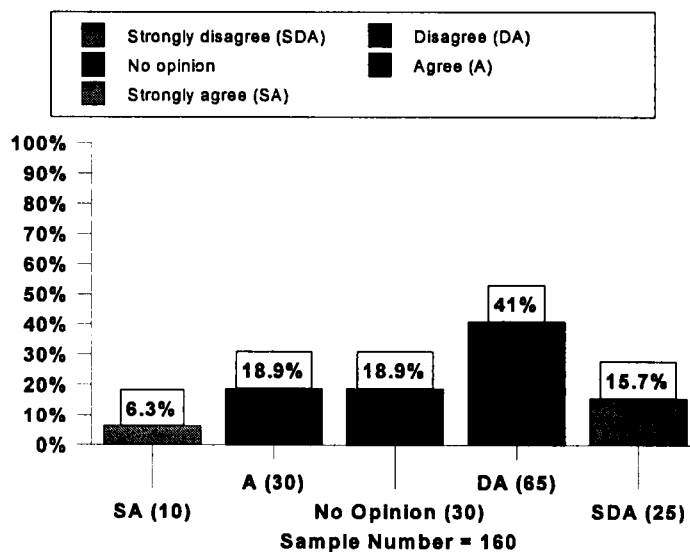


Figure 19. Question 27, I would ask to see an MSDS after working with the chemical for sometime.

(60) workers would like to be provided an MSDS after a job has started, twenty-one percent (34) had no opinion and forty-one percent (66) disagreed (Figure 20).

Research Question Three

What was the level of understanding of the MSDS as indicated through difficulty experienced with words, readability, format, and symbols?

Thirty-nine percent (63) of workers indicated that MSDS words were difficult to understand, forty-six percent (74) disagreed, and fourteen percent (23) expressed no opinion (Figure 21). Fifty-five percent (88) responded that MSDSs were easy to read, thirty-one percent (49) disagreed, and fourteen percent (23) expressed no opinion (Figure 22). There was a significant agreement between workers responding that MSDSs were difficult to understand and their response that they were easy to read, $\chi^2 (4, N = 160) = 71.5, p < .05$. Fifty-nine percent (95) of those surveyed did not find MSDSs to be lengthy, twenty-one percent (33) disagreed, and twenty percent (32) had no opinion (Figure 23). There was a significant agreement between workers responding that MSDSs were easy to read and their opinion that they were not too lengthy, $\chi^2 (4, N = 160) = 20.9, p < .05$. Thirty-seven percent (59) of the workers questioned thought the MSDS had a confusing format, forty-two percent (67) disagreed, while twenty-one percent (34) had no opinion (Figure 24). There was also significant agreement between workers responding the MSDSs were easy to read and their responses that the

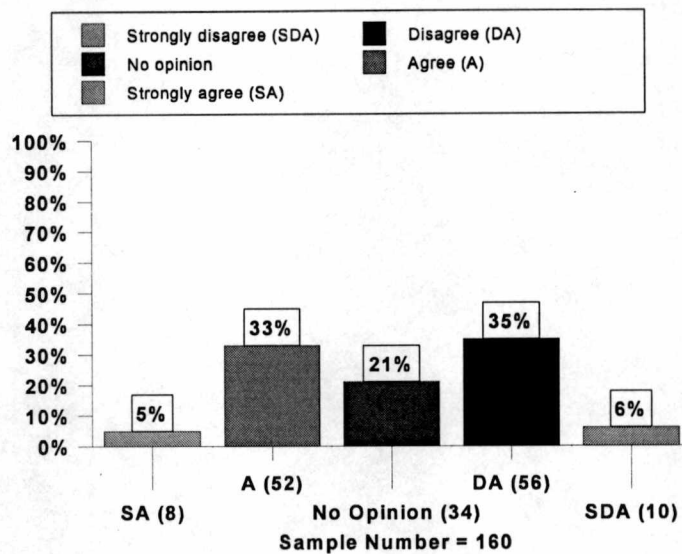


Figure 20. Question 25, I would ask to see an MSDS after the job has started.

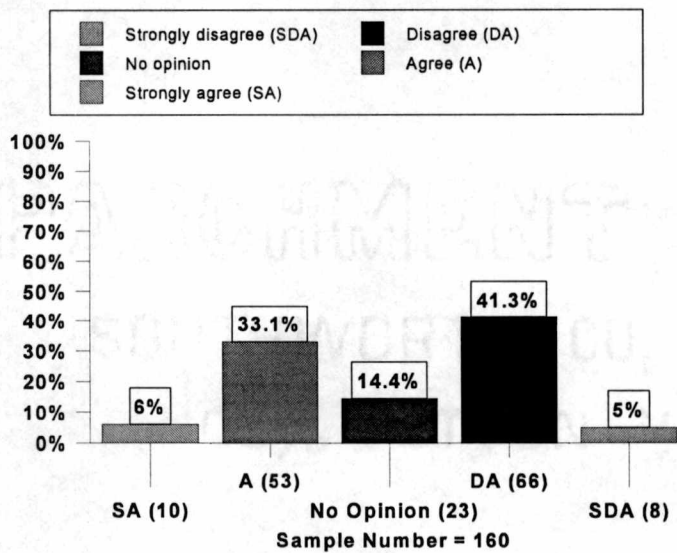


Figure 21. Question 28, my opinion about the MSDS is its words are difficult to understand.

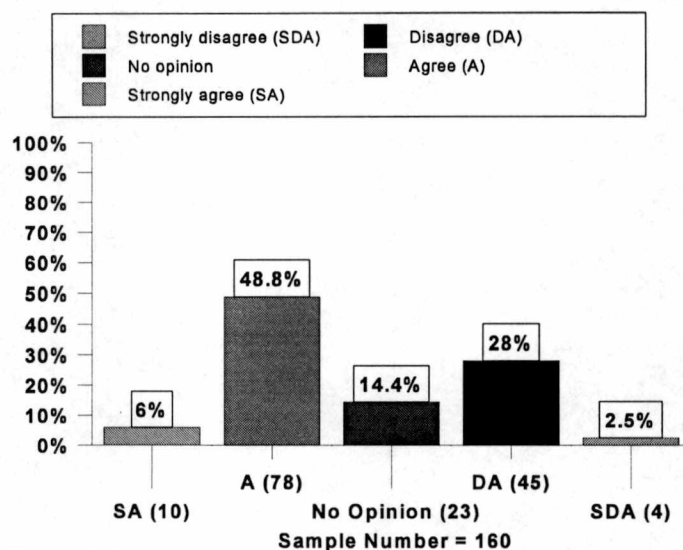


Figure 22. Question 29, my opinion about the MSDS is it is easy to read.

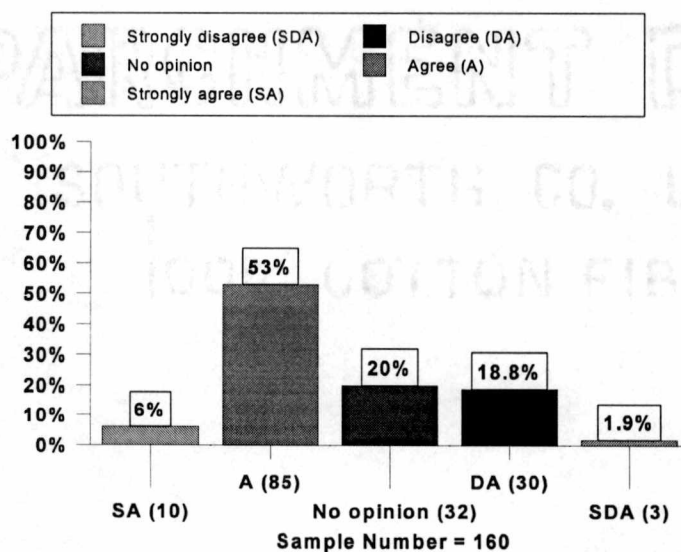


Figure 23. Question 30, my opinion of the MSDS is it is not too long to read.

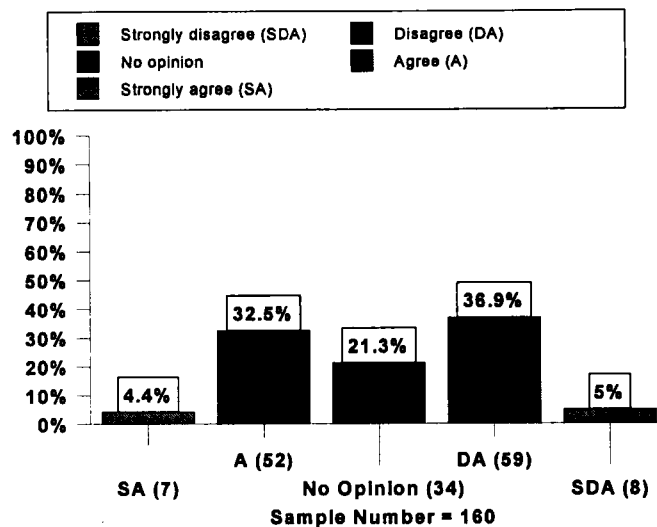


Figure 24. Question 31, my opinion about the MSDS is it has a confusing format.

format was confusing, $\chi^2 (4, N = 160) = 56.5, p < .05$. Symbols used in MSDSs were found to be easy to understand by sixty-four percent (103) workers surveyed (Figure 25). There was also significant agreement between workers responding the MSDSs were easy to read and their responses that the symbols were easy to understand, $\chi^2 (4, N = 160) = 56.8, p < .05$.

Research Question Four

What was the level of accessibility of MSDSs to workers as indicated by availability/response to requests and methods of response?

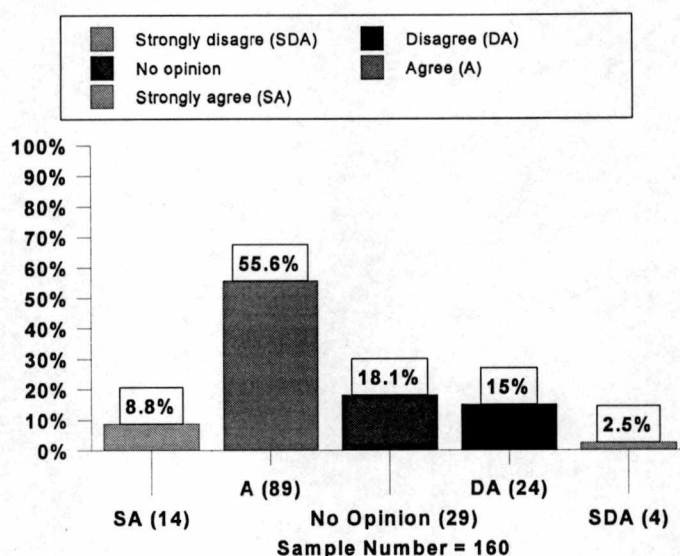


Figure 25. Question 32, my opinion about the MSDS is its symbols are easy to understand.

Eighty-eight percent (140) of workers evaluated indicated that MSDSs were available during the workshift (Figure 26). Three percent (5) of the individuals said they were not available during the workshift and twenty-four percent (27) of the workers replied they never see an MSDS (Figure 27). When questioned as to when management provides the MSDS, fifty-two percent (83) of the workers indicated receipt of MSDSs during the planning stages of jobs (Figure 28). There was also significant agreement between workers who wanted to see MSDSs in the planning stages of work and when they responded management was providing them, $\chi^2 (6, N = 160) = 60.8, p < .05$. Fifty-eight (93) percent indicated they see MSDSs during the job safety briefing (Figure 29).

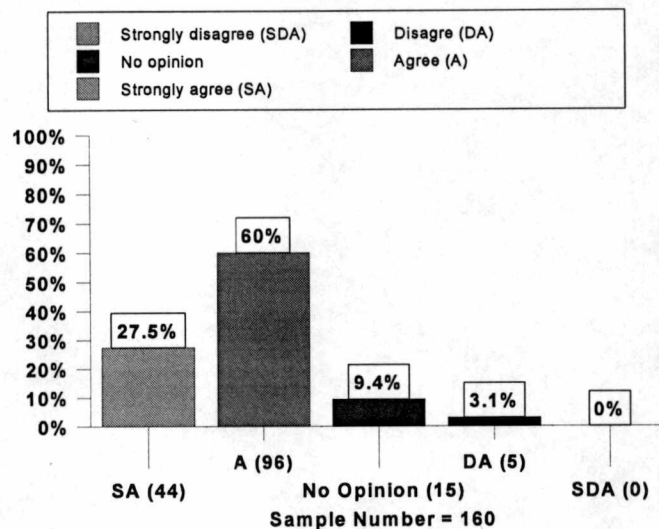


Figure 26. Question 11, MSDS sheets are available to me within the workshift at my worksite.

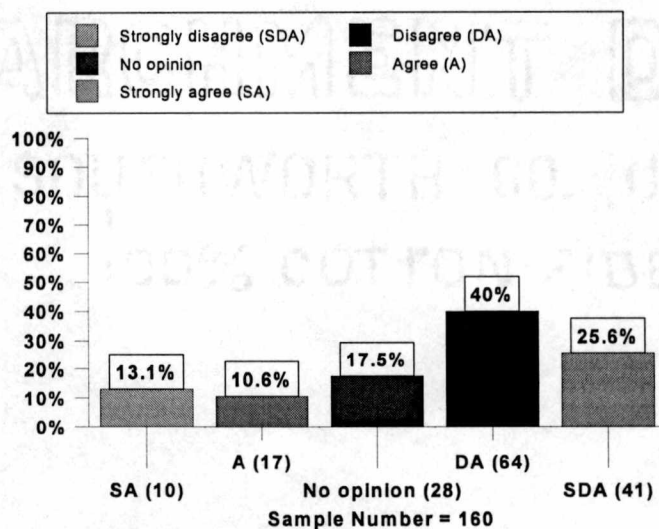


Figure 27. Question 22, I never see an MSDS.

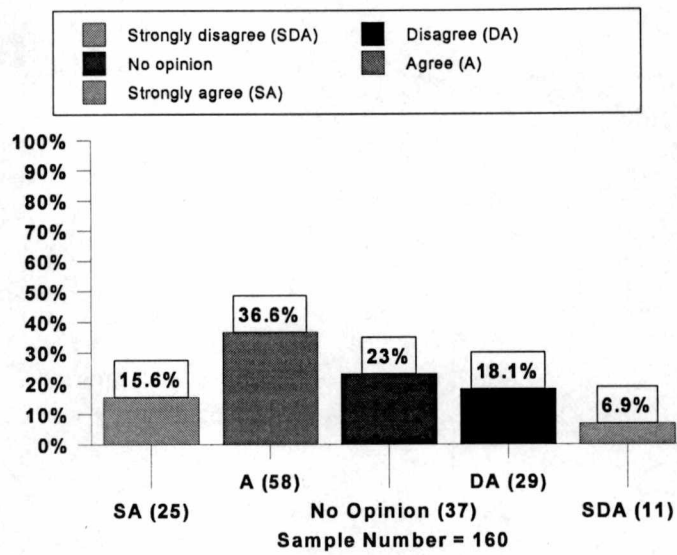


Figure 28. Question 16, I am provided MSDS during job planning.

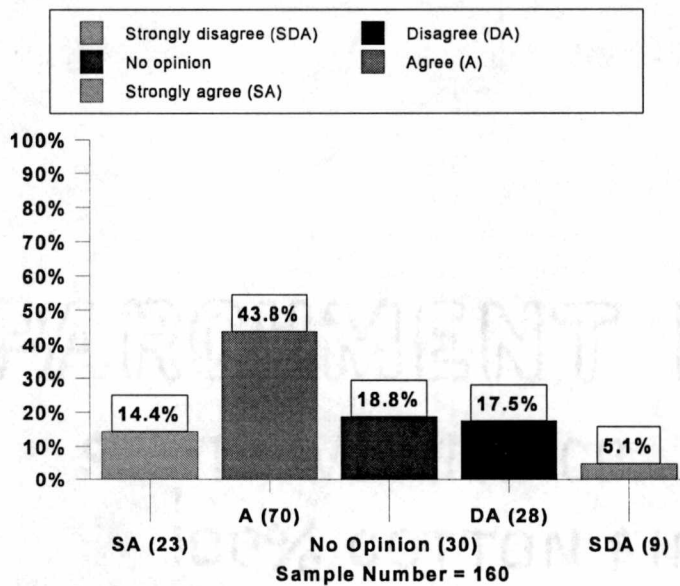


Figure 29. Question 17, I am provided MSDS at the safety briefing at the start of job.

There was significant agreement between the workers wanting to see MSDS at safety briefings prior to work and when management was providing them, $\chi^2 (4, N = 160) = 51.1, p < .05$. Seventy-two percent (115) of the workers surveyed agreed they see an MSDS when first introduced to a new chemical (Figure 30). There was significant agreement between the workers wanting to see an MSDS when first introduced to a chemical and when management was providing them as indicated by the same workers, $\chi^2 (4, N = 160) = 19.6, p < .05$. Thirty-six percent (57) of the workers responded that MSDS are provided when a safety and health inspector comes around and twenty-seven percent (49) disagreed (Figure 31). Eighteen percent of workers (29) indicated that MSDSs were provided after the job was finished and forty-nine percent (78) disagreed (Figure 32). Thirty-seven percent (59) of the workers indicated they were provided an MSDS after an accident or spill (Figure 33). Seventy-two percent (115) workers indicated they had requested chemical hazard information on one or more chemicals and twenty-eight percent (45) had not (Figure 34). MSDS information was provided verbally to 26 (22.2%) workers, in written format to 35 (29.9%), through the use of computers to 6 (5.1%), and through all three methods to 50 (42.7%) of the workers requesting information (Figure 35). When provided in written format 99 (88.4%) workers requesting chemical information received it as a written MSDS (Figure 36).

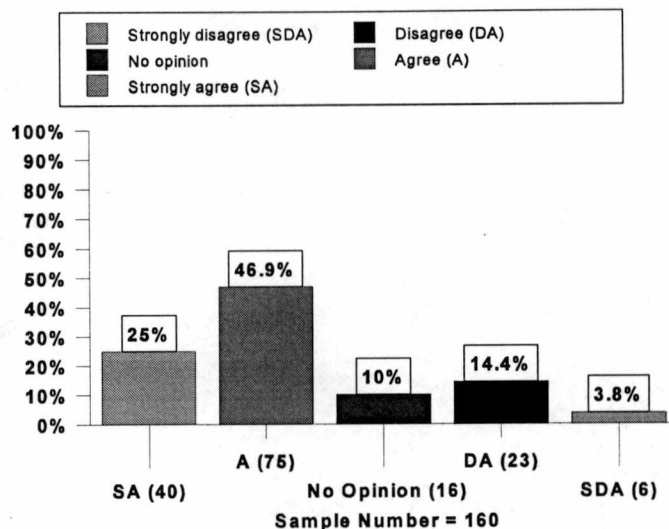


Figure 30. Question 18, I am provided MSDS when first introduced to a chemical.

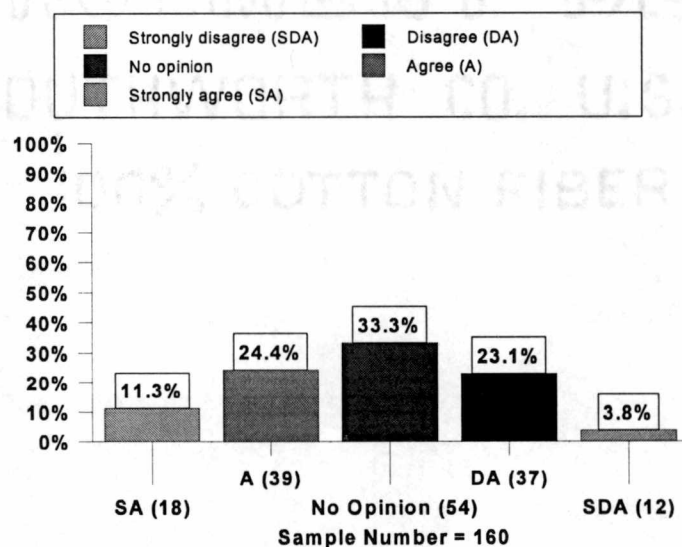


Figure 31. Question 19, I am provided MSDS when a health and safety inspector comes around.

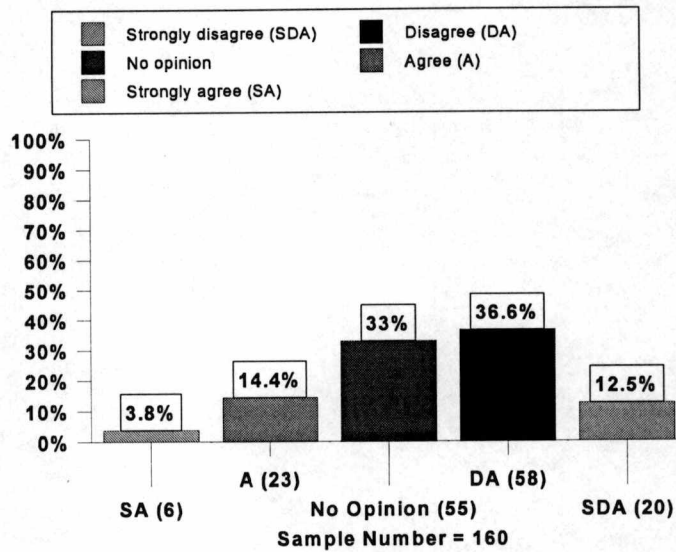


Figure 32. Question 20, I am provided MSDS after the job has finished.

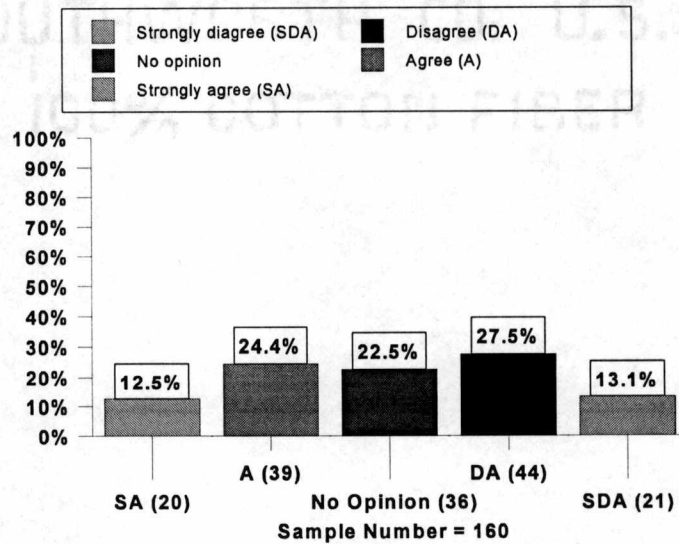


Figure 33. Question 21, I am provided MSDS after an accident or spill.

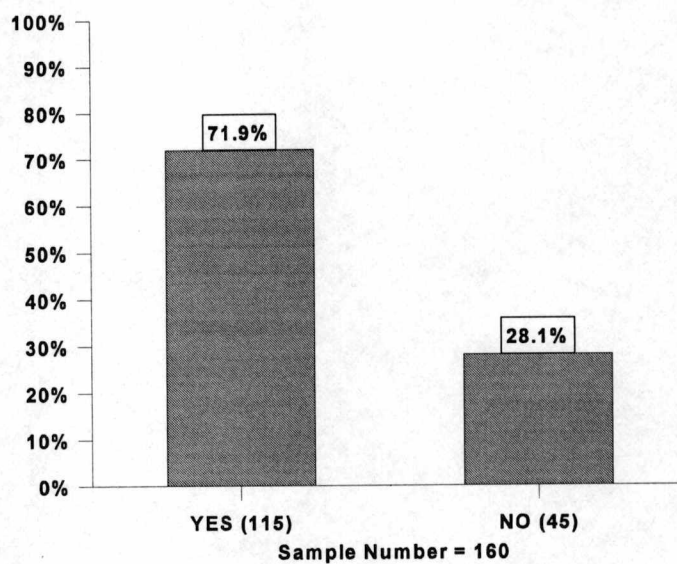


Figure 34. Question 6a, have you ever requested information on one or more chemicals with which you worked?

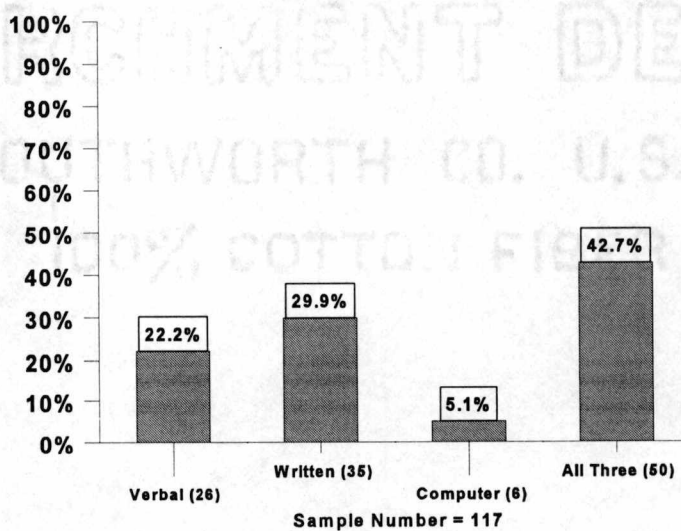


Figure 35. Question 6b, was the information you requested given verbally, written, computer or all three?

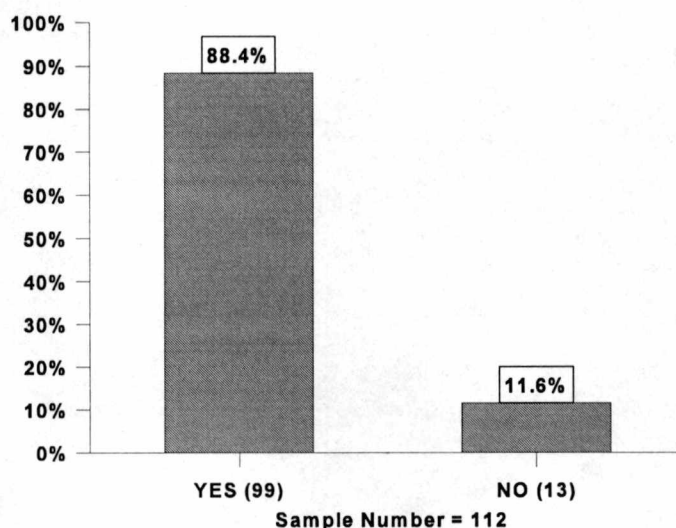


Figure 36. Question 6c, If the requested information from management on chemicals was written, was it an MSDS?

Research Question Five

What was the level of acceptability of MSDSs to workers as indicated through satisfaction with information provided, frequency of use, and altered work habits?

Of the workers studied, ninety-one percent (146) indicated that MSDSs were satisfactory to very satisfactory in providing protective information (Figure 37). Of those requesting chemical hazard information, ninety-two percent (108) said that MSDSs answered their questions (Figure 38). Thirty-four percent (54) workers indicated use of MSDS all the time to half the time, while sixty-six percent (106) rarely to almost never used them (Figure 39). Seventy-nine

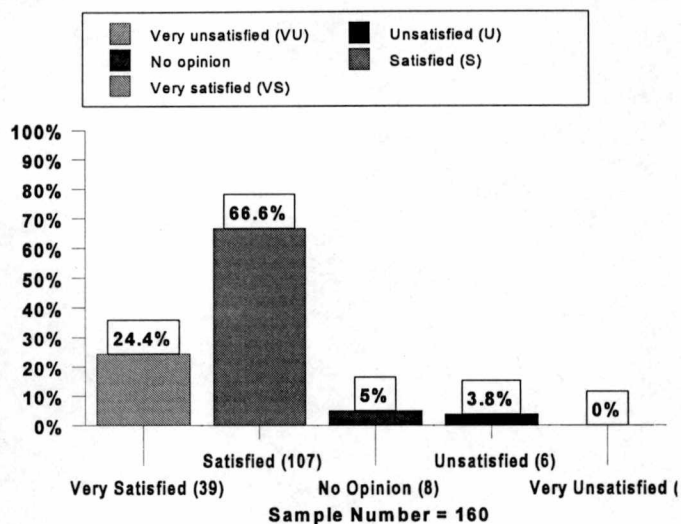


Figure 37. Question 13, to what extent do you think MSDSs are satisfactory in providing information to protect yourself?

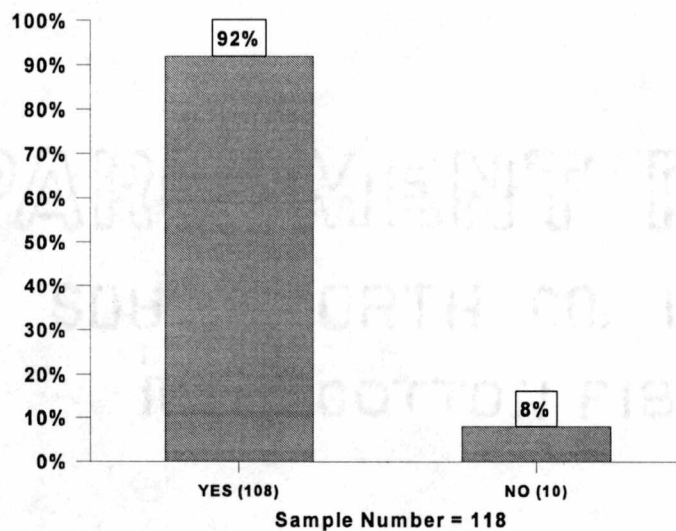


Figure 38. Question 6d, did the information answer your questions?

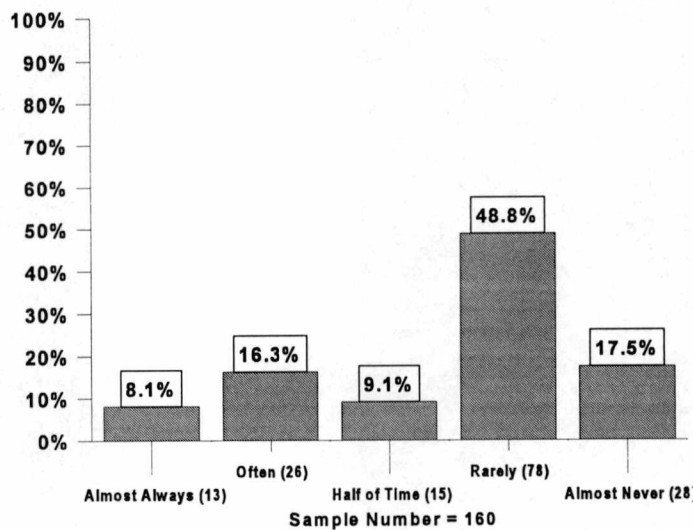


Figure 39. Question 14, how often do you use an MSDS when working with a chemical on your job?

percent (126) of union workers surveyed had altered work habits toward safer actions due to MSDSs (Figure 40). There was a significant agreement between numbers of workers changing work habits to more safe procedures and their belief that chemicals are harmful, $\chi^2 (6, N = 160) = 22.6, p < .05$. Workers indicated that they approved the use of health hazard ratings in MSDSs by a margin of ninety-six percent (154) and ninety percent (144) would like to see such ratings on labels (Figure 41 and 42). Sixty-eight percent (109) of the union workers considered the health hazard ratings nonconfusing, with thirty-eight percent (61) suggesting that written information would be more acceptable (Figures 43 and 44). Health hazard ratings on MSDSs by a margin of eighty-one percent (129) were considered appropriate by workers studied (Figure 45).

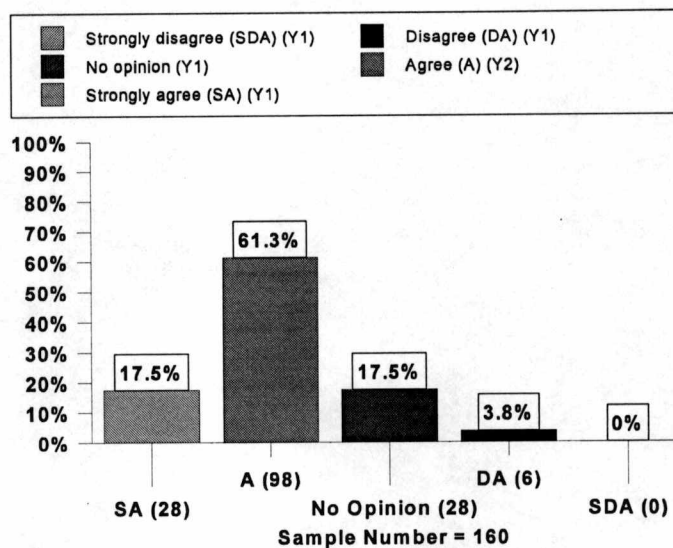


Figure 40. Question 10, I have changed to safer actions in my work as a result of reading MSDS information on chemicals.

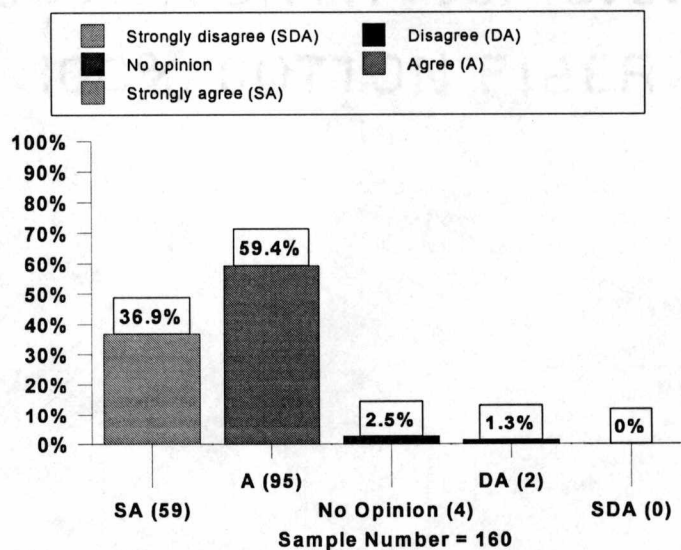


Figure 41. Question 33, health hazard number ratings are useful.

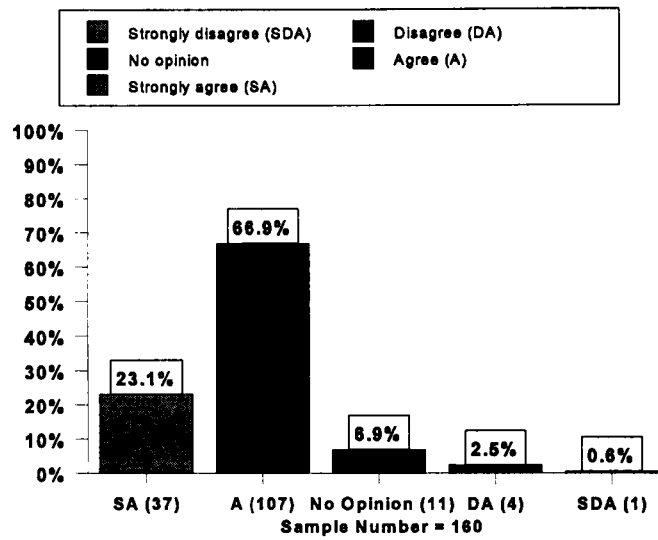


Figure 42. Question 37, health hazard rating numbers should be on labels.

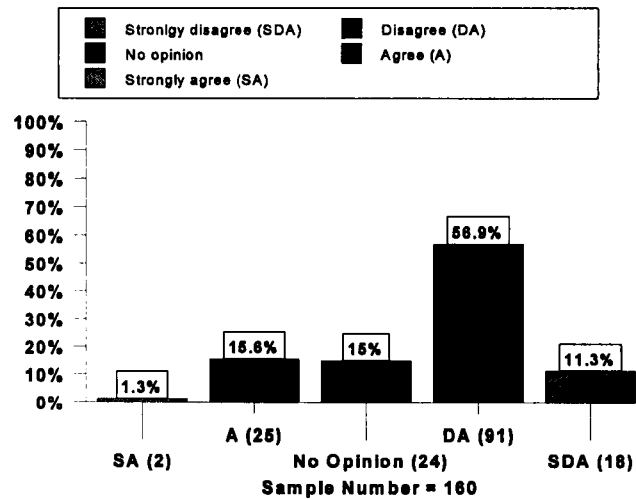


Figure 43. Question 34, health hazard rating numbers are confusing.

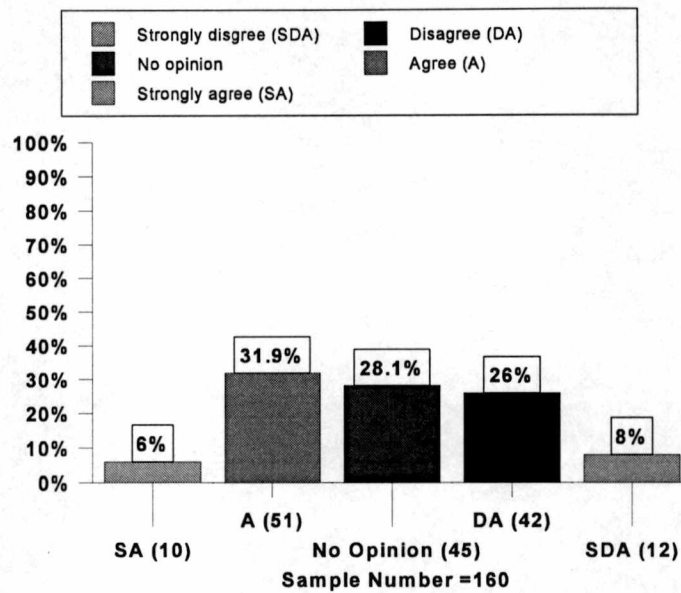


Figure 44. Question 35, regarding health hazard rating numbers, written information would be better.

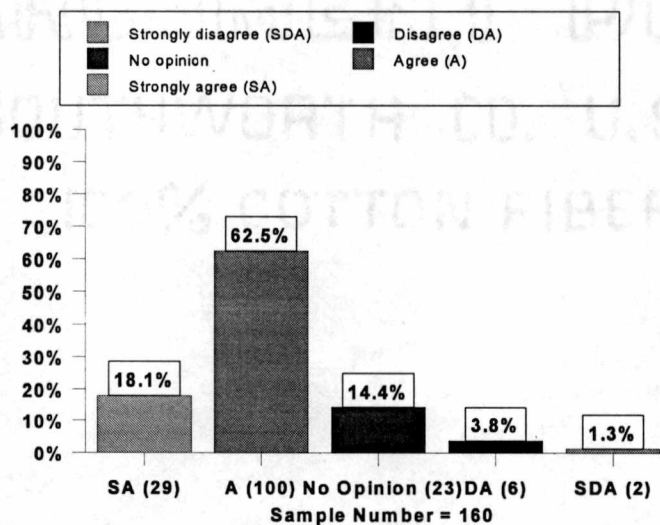


Figure 45. Question 36, health hazard rating numbers should be on the MSDS.

Research Question Six

What beliefs were held by union workers as to risk or threat associated with chemical usage?

Ninety-eight percent (157) of the workers indicated that chemicals are a threat to their health (Figure 46). Eighty-six percent (137) of these same workers said the chemicals they work with would affect their health (Figure 47). Only six percent (10) of the workers felt that the risk of chemical hazards at the laboratory was blown out of proportion (Figure 48).

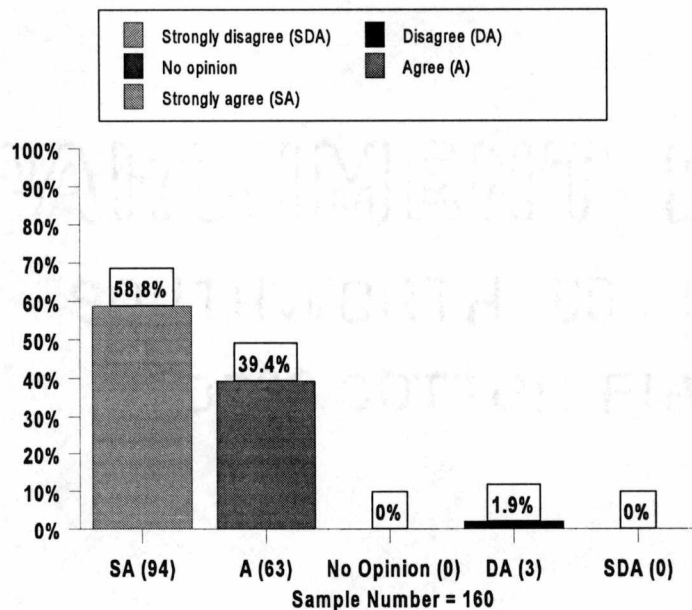


Figure 46. Question 39, in my opinion chemicals can be a threat to your health.

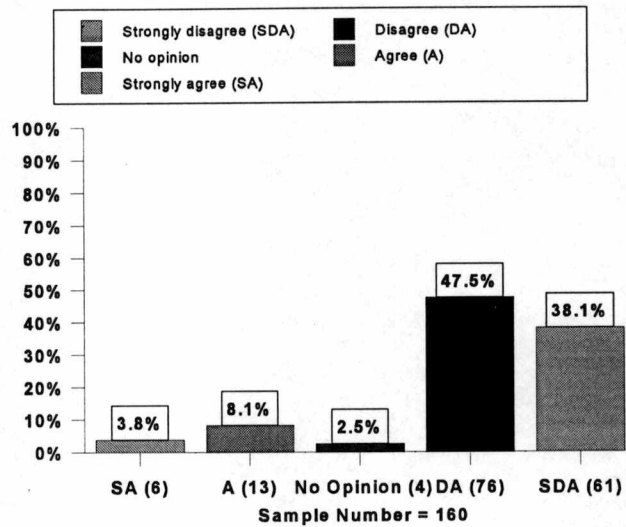


Figure 47. Question 38, in my opinion chemicals I work with won't affect my health.

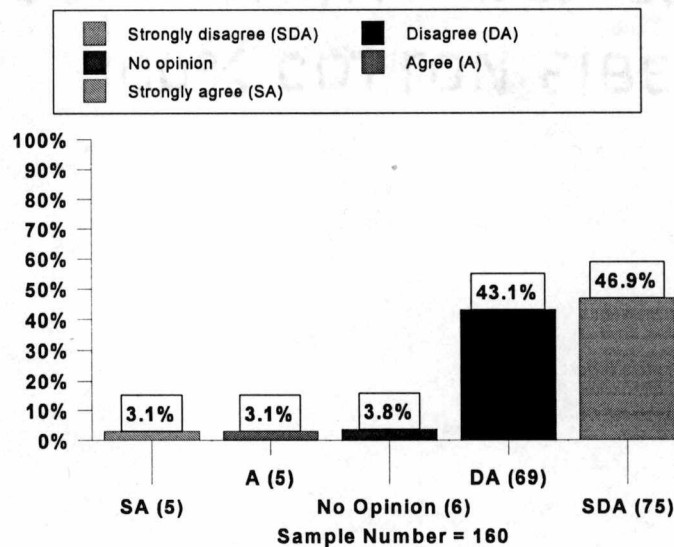


Figure 48. Question 40, in my opinion this whole thing about chemical hazards is blown out of proportion.

The preceding portion of this chapter utilized descriptive statistics to report on results of the MSDS efficacy inventory through questions answered by workers pertaining to acceptability and usage of the MSDS at the national laboratory. The second part of this chapter will report the results of parametric testing of the hypotheses on the ability of the MSDS to diffuse information to the worker and compare three different MSDS formats.

Null Hypothesis One

H_{01} : The use of OSHA type MSDS as a reference does not significantly provide the worker with safety and health information.

The t-test was used to determine whether or not the OSHA type MSDS made any significant difference in diffusing information to the worker. The null hypothesis was not rejected at the .05 significance level if the t-test statistic was < 1.685 with 39 degrees of freedom (df) for a one-tailed test. The t-statistic calculated value was 9.88 which indicated a significant difference; therefore, the hypothesis was rejected. There was a significant difference between the pretest and posttest knowledge of the workers on safety and health information. The data are presented in Table 3.

Null Hypothesis Two

H_{02} : The use of the CMA/ANSI Z400.1 MSDS form as a reference does not significantly provide the worker with safety and health information.

The t-test was used to determine whether or not the CMA/ANSI Z400.1

Table 3. The t-tests for pretest and posttest average gain scores ($N = 40$) on three different MSDS formats reported as (NS) not significant or (S) significant

Form	Mean	Standard Deviation	t-statistic*	5% Significance
Control	-0.18	1.40	-0.82	NS
ICSC	4.42	2.38	11.76	S
CMA/ANSI	3.18	2.09	9.59	S
OSHA Type	3.98	2.55	9.88	S

* $t(39, .05) = 1.685$

MSDS form made any significant difference in diffusing information to the worker. The null hypothesis was not rejected at the .05 significance level if the t-test statistic was < 1.685 with 39 degrees of freedom (df) for a one-tailed test. The t-statistic calculated value was 9.59 which indicated a significant difference; therefore, the hypothesis was rejected. There was a significant difference between pretest and posttest knowledge of the workers on safety and health information. The data are presented in Table 3.

Null Hypothesis Three

H_{03} : The use of the ICSC MSDS form as a reference does not significantly provide the worker with safety and health information.

The t-test was used to determine whether or not the ICSC MSDS form

made any significant difference in diffusing information to the worker. The null hypothesis was not rejected at the .05 significance level if the t-test statistic was < 1.685 with 39 degrees of freedom (df) for a one-tailed test. The t-statistic calculated value was 11.76 which indicated a significant difference; therefore, the hypothesis was rejected. There was a significant difference between pretest and posttest knowledge of the workers on safety and health information. The data are presented in Table 3.

Null Hypothesis Four

H_{04} : There is no significant difference between the OSHA type MSDS, the CMA/ANSI Z400.1 form, and the ICSC MSDS form as a reference to the worker on safety and health information.

The statistical method of analysis of variance (ANOVA) was used to determine whether or not there were any significant differences for the average gain scores among the three forms in diffusing information to workers. The null hypothesis was tested using ANOVA which compared "between forms" variability to "within forms" variability by a *F*-test. The calculated *F*-value was 2.89 which was less than the critical *F*-value of 3.08 for 2 df and 117 df at the .05 level of significance; therefore, the hypothesis was not rejected. There was no significant difference among the average gain scores over all questions and total gain scores for the three forms (Figure 49 and 50). ANOVA tables are presented in Table 4 and Table 5.

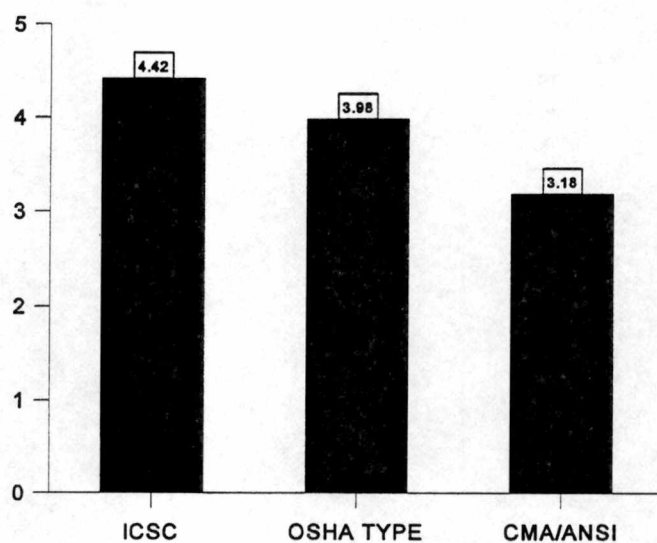


Figure 49. Average gain scores per question for three different MSDS forms.

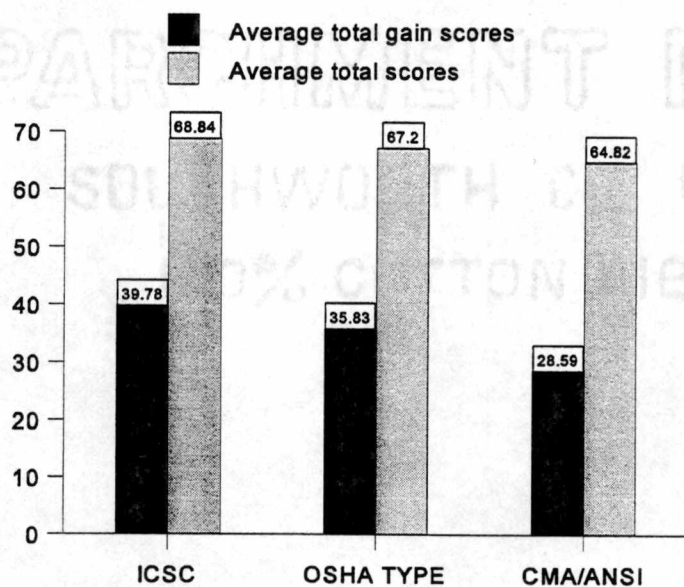


Figure 50. Average total scores and average total gain scores for three different MSDS forms posttest.

Table 4. ANOVA summary table for experimental design comparing mean gain scores of three different MSDSs

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-Value ^(a)
Between forms	2	31.82	15.91	2.89
Within forms	117	644.697	5.51	
Corrected total	119	676.51		

(a) The percentile point for an F distribution with 2 and 117 degrees of freedom at the .05 significance level is $F(2, 117, 0.05) = 3.08$.

Table 5. ANOVA summary table for experimental design comparing average gain scores of three different MSDSs to a control group

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-Value ^(a)
Between forms	3	521.57	173.91	37.62
Within forms	156	721.11	4.63	
Corrected total	159	1242.83		

(a) The percentile point for an F distribution with 3 and 156 degrees of freedom at the .05 level of significance is $F(3, 156, 0.05) = 2.66$.

Null Hypothesis Five

H_{05} : There is no significant difference between the OSHA type form 174 MSDS, the CMA/ANSI Z400.1 form, ICSC form, and the control group.

The analysis of variance was used to determine whether or not there was a significant difference between the average gain scores of an OSHA type form, CMA/ANSI Z400.1, ICSC forms, and the control group. Dunnett's test was then used to compare the average gain scores for each form with the control. Using the ANOVA, to not reject the hypothesis, the critical F -value had to be $< .66$ with 3 df and 156 df at the .05 level of significance. The calculated F -value was 37.63 which was significant at the .05 level; therefore, the hypothesis was rejected. The ANOVA table is presented in Table 5. Dunnett's test is presented for each form at the 95% confidence interval on the difference between the average gain scores for the forms and the average gain score for the control. If the lower confidence intervals included zero, there would be no gain using the form. All the forms reflected in Table 6, do show an increase in the average gain scores over the control because all the lower confidence intervals exceed zero. There is a significant difference between the average gain scores of each form and the control, $p < .05$.

Null Hypothesis Six

H_{06} : There is no significant difference in the average gain scores achieved on the OSHA type Form, the CMA/ANSI Z400.1 form, and the ICSC form between groupings on number of chemicals used.

Table 6. Dunnett's test presented as 95% confidence intervals for an experimental design comparing average gain scores of each MSDS to the control group

Form	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
ICSC - control*	3.60	4.60	5.60
OSHA TYPE - control*	3.16	4.16	5.16
CMA/ANSI -control*	2.34	3.36	4.36

* $p < .05$.

For each form an analysis of variance was used to determine whether or not there was a significant difference between the average gain scores among groupings on the number of chemicals used. The probabilities of the calculated F -values were less than critical F -value for all the forms, $p > .05$, indicating no significant difference when compared between grouping on the number of chemicals used reflected in Table 7. The hypothesis was not rejected.

Null Hypothesis Seven

H_{07} : There is no significant difference in the average gain scores achieved on the OSHA type form, CMA/ANSI Z400.1 form, and ICSC form between groupings on grade level completed.

For each form an analysis of variance was used to determine whether or

Table 7. Hypotheses H6, H7, H8, and H9 based on the results of the MSDS inventory and MSDS comprehensibility test

Hypotheses	ANOVA Probabilities	Comment
6. There are no significant differences in the average test scores achieved on OSHA type form, CMA/ANSI, and ICSC forms between groupings on the number of chemicals used.	ICSC: 0.09 ANSI: 0.86 OSHA: 0.66	For each form, there are no significance differences among the grouping on the number of chemicals used.
7. There are no significant differences in the average test scores achieved on OSHA type form, CMA/ANSI, and ICSC forms between groupings on grade level completed.	ICSC: 0.69 ANSI: 0.77 OSHA: 0.16	For each form, there are no significance differences among the grouping on grade level completed.
8. There are no significant differences in the average test scores achieved on OSHA type form, CMA/ANSI, and ICSC forms between groupings on years worked at the national laboratory.	ICSC: 0.60 ANSI: 0.30 OSHA: 0.81	For each form, there are no significance differences among the grouping on years worked at the national laboratory.
9. There are no significant differences in the average test scores achieved on OSHA type form, CMA/ANSI and ICSC forms between groupings on age.	ICSC: 0.11 ANSI: 0.70 OSHA: 0.04	There are no significant differences among the grouping on age for ICSC and ANSI/CMA. <u>Note:</u> The results on OSHA type form were significant between age groups: 40-49 and 50-59.

not there was a significant difference between the average gain scores among groupings on the grade level completed. The probabilities of the calculated F -values were less than the critical F -value for all the forms, $p > .05$, indicating no significant difference when compared between groupings on grade level completed reflected in Table 7. The hypothesis was not rejected.

Null Hypothesis Eight

H_{08} : There is no significant difference in the average gain scores achieved on the OSHA type form, CMA/ANSI Z400.1, and ICSC forms between groupings in years worked at the national laboratory.

For each form analysis of variance was used to determine whether or not there was a significant difference between the average gain scores among groupings on years worked at the national laboratory. The probabilities of the calculated F -values were less than the critical F -value for all forms, $p > .05$, indicating no significant difference when compared between groupings on years worked at the national laboratory reflected in Table 7. The hypothesis was not rejected.

Null Hypothesis Nine

H_{09} : There is no significant difference in the average gain scores achieved on the OSHA type form, CMA/ANSI Z400.1, and ICSC forms between groupings on age.

For each form an analysis of variance was used to determine whether or not there was a significant difference between the average gain scores among grouping on age. The probabilities of the calculated F -value for the CMA/ANSI

Z400.1, and ICSC forms were greater than the critical F -value, $p > .05$, indicating no significant difference when compared between grouping on age reflected in Table 7. Using the multiple comparison Sidak's t -test the average gain scores for the 40-49 age group were found to be significantly different from average gain scores for age groups 50-59 for the OSHA type form MSDS, $p < .05$. The null hypothesis was rejected.

Null Hypothesis Ten

H_{010} : There is no significant difference in the average gain scores achieved on each question of the MSDS comprehensibility test between the OSHA type form, CMA/ANSI Form Z400.1, and the ICSC form.

The analysis of variance was used to determine whether or not there was a significant difference in the average gain scores achieved on each question of the MSDS comprehensibility test between the OSHA type form, CMA/ANSI Z400.1, and the ICSC form. Using the ANOVA, to not reject the hypothesis, the critical value of F had to be < 3.08 with 2 df and 117 df at the .05 level of significance. The calculated F -values were less than the critical F -value for questions 1, 3, 6, and 7 respectively, $p > .05$, Table 8. Using the Sidak's t -multiple comparison test questions 2, 4, 5, 8, and 9 were found to be significantly different in average gain scores, $p < .05$ (Figures 51 and 52) and as reflected in Table 8. On question ten, excluding the ICSC format and OSHA type form outscored the CMA/ANSI Z400.1 form in total average scores but not significantly as shown in Table 9. In Figure 52, values connected by the same line are not significantly different at the .05 level. The hypothesis was rejected.

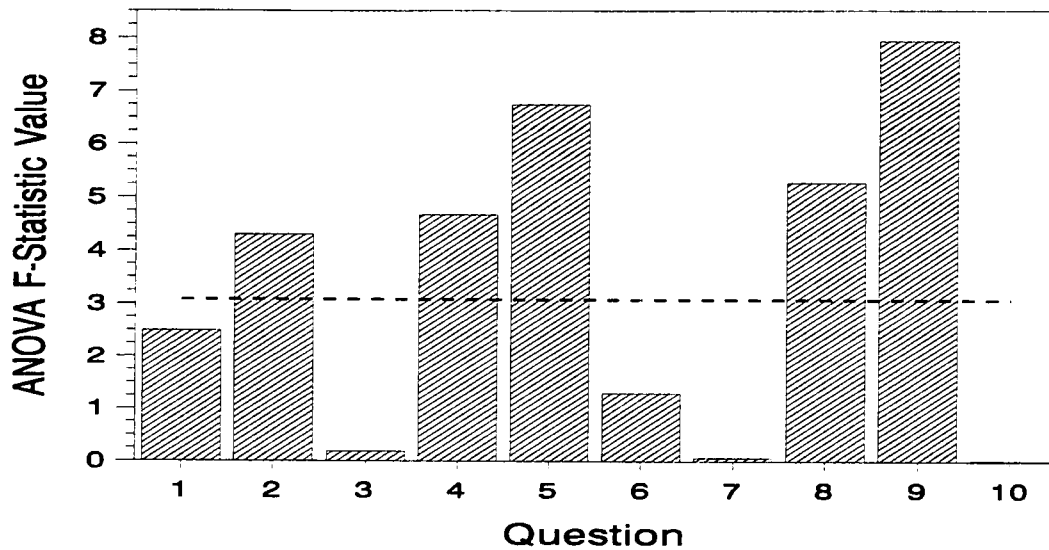


Figure 51. ANOVA F -statistic values for comparing the average gain scores of the three forms for each question. Dash line is the percentile value of the F -distribution at the 5% significance level.

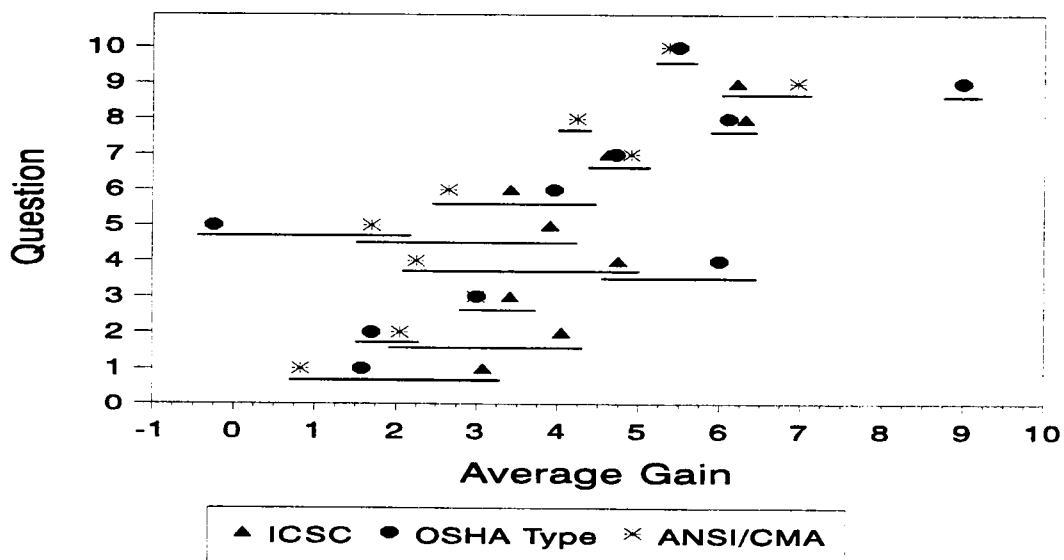


Figure 52. Average gain scores for each question on a form. Values connected by the same line are not significantly different at the 5% significance level.

Table 8. ANOVA summary table for experimental design comparing average gain scores of questions 1-9 of the Measurement of MSDS Comprehensibility test for three different MSDSs

Question	Source	Degrees of Freedom	Sum of Differences	Mean Square	F- value ^(a)
1	Between questions	2	105.11	52.56	2.49
	Within questions	117	2470.49	21.11	
	Corrected total	119	2575.21		
2	Between questions	2	128.60	64.30	4.30
	Within questions	117	1748.20	14.94	
	Corrected total	119	1876.80		
3	Between questions	2	4.60	2.30	0.18
	Within questions	117	1465.53	12.53	
	Corrected total	119	1470.13		
4	Between questions	2	291.67	145.83	4.67
	Within questions	117	3655.00	31.24	
	Corrected total	119	3946.67		
5	Between questions	2	345.88	172.94	6.74
	Within questions	117	3001.89	25.66	
	Corrected total	119	3347.77		

^(a) The percentile point for an *F* distribution with 2 and 117 degrees of freedom at the .05 significance level is *F* (2, 117, .05) = 3.08.

Table 8 (Continued)

ANOVA summary table for experimental design comparing average gain scores of questions 1-9 of the Measurement of MSDS Comprehensibility test for three different MSDSs

Question	Source	Degrees of Freedom	Sum of Differences	Mean Square	F-value ^(a)
6	Between questions	2	34.75	17.38	1.29
	Within questions	117	1572.41	13.44	
	Corrected total	119	1607.16		
7	Between questions	2	1.74	0.87	0.06
	Within questions	117	1629.96	13.93	
	Corrected total	119	1631.70		
8	Between questions	2	105.36	52.68	5.27
	Within questions	117	1168.90	9.99	
	Corrected total	119	1274.26		
9	Between questions	2	165.47	82.74	7.93
	Within questions	117	1220.32	10.43	
	Corrected total	119	1385.79		

^(a) The percentile point for an F distribution with 2 and 117 degrees of freedom at the .05 significance level is $F(2, 117, .05) = 3.08$.

Table 9 ANOVA summary table for experimental design comparing average gain scores of question 10 of the Measurement of MSDS Comprehensibility test for three different MSDSs

Question	Source	Degrees of Freedom	Sum of Differences	Mean Square	F-value ^(a)
10.	Between questions	1	0.31	0.31	0.01
	Within questions	78	2159.37	27.68	
	Corrected total	79	2159.68		

- ^(a) The percentile point for an F distribution with 1 and 78 degrees of freedom at the .05 significance level is $F(1, 78, .05) = 1.99$.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, DISCUSSION, RECOMMENDATIONS, AND IMPLICATIONS

Summary

The purposes of this study were to determine how well the Material Safety Data Sheet diffuses information to workers; compare the efficacy of an OSHA type form, CMA/ANSI Z400.1 format, and the International Chemical Safety Card (ICSC); and determine worker acceptability and understanding at a large national laboratory.

As demonstrated by the literature review a paucity of studies on the efficacy of the MSDS and worker acceptance have been accomplished since the Hazcom Standard was implemented in 1983. Studies conducted by Nelkin and Brown (1984), Hadden (1988), Kearney/Centaur, Inc. (1991b), Lu and Moure-Eraso (1993), Kolp, et al, (1993) were qualitative or descriptive in design and analysis. The perception given by the results of these studies was that MSDS formats were hard for workers to understand and that content and readability needed improvement. A few of the studies suggested a more simple design be attempted, while others advocated more information be added to service the needs of a diverse user group. The OSHA contracted Kearney/Centaur study in its final report urged further research on the role format played in comprehension by workers.

This study emerged from the speculation that format might play a role in

MSDS comprehension and as a result of the recommendation for more study by the Kearney/Centaur report. A further stimulus to conduct the study was the need of a large national laboratory to assess its MSDS program through evaluation of union worker acceptability, understanding, and use of the forms.

The 160 workers studied were selected from a population of 824 members of the Atomic Trades and Labor Council employed at the national laboratory. Eighteen crafts comprised the 160 workers. Instrumentation utilized in the study consisted of a forty-question inventory on acceptability of the MSDS to the worker and a ten-question MSDS comprehensibility test which was administered twice to the worker. The treatments or independent variables, three differently formatted MSDSs, were controlled for level of readability and specific chemical addressed. The treatments were introduced during the posttest. Relationships between the variables of worker's age, education level, years worked, and the number of chemicals used were evaluated for effect on the efficacy of the MSDS.

Six research questions and ten hypotheses were developed for this study. Research questions, answered through use of the MSDS efficacy inventory, were focused to describe acceptability of the MSDS. The questions were used to identify demographics, level of training on the MSDS, level of understanding of the MSDS, level of accessibility and acceptability, and health belief impact on MSDS usage. The results of the MSDS efficacy inventory were analyzed descriptively and with the use of chi-square to show dependency between answers to questions.

The null hypotheses were developed to test the efficacy of the MSDS in diffusing information to workers; compare the three different formats; and determine the efficacy of each in answering specific questions addressed on the MSDS comprehensibility test.

In an experimental design workers were randomly assigned to four different test groups of forty individuals. Using an MSDS comprehensibility test, all groups were pretested on their knowledge about a specific chemical and then posttested using the same test. Posttest questions were randomized in comparison to the pretest. Each individual in the three groups randomly received one of the three differently formatted MSDSs to use as a reference in answering questions on the posttest. MSDSs were not provided during the pretest. A fourth group served as a control receiving the pretest and posttest without an MSDS reference sheet. The workers were not aware that they were going to be tested on MSDSs nor of the chemical to be addressed. Parametric statistics including one-tailed t-tests, ANOVAs, and multiple comparison tests at a .05 level of significance were utilized to identify any significant differences between the three MSDS formats in their ability to diffuse information to the workers studied. The data from the study were gathered from questions and testing administered in a classroom over a one hour period.

Findings

The following section outlines the major findings, first in terms of MSDS acceptability to the union workers studied and then as related to MSDS efficacy.

Acceptability Inventory

1. The sample population consisted of 140 males and 20 females of which 80% were at or above the age of forty. Sixty-nine percent of this middle-aged workforce had achieved a ninth to twelfth grade education and thirty percent had some level of college work. The sample population was almost evenly split in the number of years worked at the national laboratory with forty-nine percent having worked ten years or less and fifty percent greater than ten years. There were eighteen job crafts identified in the sample population, predominantly including labor/pest controllers, carpenters, painters, and pipefitters. Ninety percent of this worker population worked with chemicals on a weekly basis requiring the use of MSDSs.

2. Ninety-five percent of the union workers studied had undergone training on MSDSs either on the job, in a classroom or both. The union workers agreed that training on the MSDS at the national laboratory met with their satisfaction. Eighty-eight percent of the sample population indicated that the training helped them better understand the MSDS. As reflected by responses to the MSDS inventory, a majority of the workers knew appropriate times to request an MSDS, e.g., during planning stages, safety briefings, and prior to working with a chemical.

3. Workers responding were in disagreement as to whether MSDSs were difficult to understand, with thirty-nine percent indicating they were and forty-six percent disagreeing. Over half of the workers indicated the MSDS was easy to read and one-third disagreed. Most workers did not think MSDSs were too

lengthy with twenty percent in disagreement. Almost half of the union workers studied did not consider the MSDS format to be confusing. However, one-third disagreed. Workers also responded that symbols found on MSDSs were easy to read.

4. The study revealed that MSDSs were accessible to the workers studied at the laboratory during the work shift and were provided by management at the stages of work that workers wanted to see them. MSDSs were provided in written format, on computers or verbally to the workers studied and in almost half of the responses all three media were said to be available. Seventy percent of workers inventoried indicated they had requested and received MSDS information with ninety percent of those having received a hard copy MSDS.

5. Worker acceptability of the MSDS, as measured by worker satisfaction with information provided, was very high. Greater than ninety percent of workers responded that MSDSs were satisfactory to very satisfactory in providing protective information and answering questions. Acceptability as measured by worker frequency of usage was low. A third of the union workers studied responded they used MSDSs at least half to all of the time, the remainder rarely to almost never used them. Changing work habits to safer practices, as a measure of MSDS acceptability, also ranked high in that three-fourths of the workers surveyed had implemented such changes. Most of the workers surveyed also agreed with the use of health hazard ratings on MSDSs and did not consider them confusing.

6. Workers, in a consensus, agreed that chemicals were a threat to their

health including those with which they currently worked. Workers by a majority also indicated that the threat of chemicals was not blown out of proportion at the national laboratory.

Efficacy of Formats

7. The OSHA type MSDS, as a reference, made a significant difference in workers's posttest scores compared to pretest scores in a test of the workers' ability to answer health and safety questions about a particular chemical. The form significantly diffused information to workers.

8. The International Chemical Safety Card (ICSC), as a reference, made a significant difference in workers' posttest scores compared to pretest scores in a test of the workers' ability to answer health and safety questions about a particular chemical. The form significantly diffused information to workers.

9. The use of a CMA/ANSI Z400.1 type of MSDS, as a reference, made a significant difference in workers' posttest scores compared to pretest scores in a test of the workers' ability to answer health and safety questions about a particular chemical. The form significantly diffused information to workers.

10. Considering the highest average total and average total gain scores achieved by each different MSDS form there was a rank order of finish; ICSC (68.8, 39.8); OSHA type form 174 (67.2, 35.8); and CMA/ANSI Z400.1 (64.8, 28.6), respectively. However, there were no significant differences in these scores, thus in efficacy of the formats. There were significant differences in the scores of each format and the control group.

11. There were no significant differences on average gain scores among groupings on the number of chemicals used for each form.
12. There were no significant differences on average gain scores among groupings on grade level completed for each form.
13. There were no significant differences on average gain scores among the groupings on years worked at the national laboratory for each form.
14. There were no significant differences on average gain scores among the groupings on age for the ICSC and CMA/ANSI Z400.1 forms. Results on the OSHA type form revealed that the 40-49 age group scored significantly better than the 50-59 age group.
15. There were significant differences on average gain scores achieved on MSDS comprehensibility test questions 2, 4, 5, 8, and 9 between the three different forms. There were no significant differences between the forms on questions 1, 3, 6, and 7. The ICSC had the highest average gain scores on five questions followed by the OSHA type form with three and the CMA/ANSI Z400.1 form with one. On question ten, excluded from the three form comparison, the OSHA type form edged out the CMA/ANSI Z400.1 form in total average score, but not significantly (Table 9). Both, the ICSC and OSHA type form were each significantly higher on three different questions.
16. The ICSC form was significantly better than the OSHA type form at answering questions on chronic and immediate health effects. Both the ICSC and OSHA type form were significantly better than the CMA/ANSI Z400.1 form in answering fire related questions. The OSHA type form was significantly better

than the other two forms at answering spill response questions. It also was significantly better than the CMA/ANSI form at answering cancer-causing potential questions. The CMA/ANSI form was not significantly better in any of the questions asked on the MSDS comprehensibility test. Additionally, the ICSC outsourced the other two forms on questions pertaining to routes of entry and body systems immediately affected. The ICSC also outsourced the CMA/ANSI form in answering questions on chronic health effects. The OSHA type form outsourced the other two forms on what personal protective equipment to use and where to go for additional help. The CMA/ANSI Z400.1 form narrowly outsourced the other two forms on the question of first aid procedures and outsourced the OSHA type form on chronic and immediate health effects. The CMA/ANSI also outsourced the ICSC format on questions pertaining to spills and leaks.

Conclusions

Within the limitations of this study and to the extent to which the data and findings were valid and reliable, the following conclusions are made by the author.

1. Union workers studied were trained on MSDS usage, were satisfied with the training, and understood the MSDS.
2. Workers considered the MSDS to be easy to read, not too lengthy or confusing, and easy to understand.
3. There was ready access to the MSDS during the workshift or whenever requested by union workers studied.

4. High acceptability of the MSDS was demonstrated through reported satisfaction by the workers. There was however, low usage of the forms.
5. Workers inventoried perceived chemicals to be a threat to their health.
6. Each MSDS evaluated significantly diffused information to workers studied.
7. There were no significant differences in the efficacies of the three different MSDS formats.
8. Education level, number of chemicals used, and years worked at the national laboratory did not significantly effect the efficacy the MSDS.
9. Age did not influence the efficacy of the MSDS with the exception of age groupings 40-49 and 50-50 using an OSHA type format.
10. There were significant differences, when comparing scores, in how well each of the three different MSDS formats enabled workers to answer specific questions on the MSDS comprehensibility test.

Discussion

Most of the workers comprising the sample population studied reported favorably on MSDS acceptability, accessibility, and understandability. However, the finding that one-fifth to one-third of the workers did not agree the MSDS was easy to read, understand, and not too lengthy or confusing suggests further training, format changes, and content changes might need to be considered. Further, although most workers reportedly had requested to see an MSDS at some time during their jobs almost a third of those studied had never asked to

see one. The reason for this disparity needed further evaluation at the national laboratory. Considering the strong agreement found in the study between the numbers of workers that believed chemicals to be a hazard and the number that had switched to safer work practices, there should have been a greater reported use of MSDSs in the sample population. The finding of low MSDS usage in the face of perceived threat was not in keeping with the precepts of the Social Cognitive Theory and the Health Belief Model. A plausible explanation for this difference in belief and usage might have been the low number of chemicals each worker used on a weekly basis; familiarity with chemicals; and the use of standard operating procedures at the laboratory which included safety and health guidance. MSDS format testing demonstrated a significant difference in how well the 40-49 age group scored as compared to the 50-59 years age group when using the OSHA type form as a reference. Further, evaluation as to why these two age groups differed needs to be undertaken. Why the same age groups did not have a similar effect when using the other two formats needs to be studied. This finding, if not unique within the sample population, may indicate the need to study the effects of age on MSDS diffusion efficacy in older working populations which are remaining longer in the workforce.

Workers tested did not absorb a third of the information provided on each of three different MSDSs studied demonstrating weaknesses in the formats' ability to diffuse information to workers. This may suggest the MSDSs did not adhere to principles of simplicity found in Adoption Diffusion Theory.

Multiple comparison of the scores achieved by each format on each

question of the MSDS comprehensibility test demonstrated significant differences in efficacy. Considering that the level of readability and specific chemicals addressed were analogous to all forms, it was plausible that the manner in which a form presented information sought after might have affected the scores, e.g., length of explanation, jargon, sentence structure, fuzzy language, and phraseology. Further study needs to be conducted to discern the impact of these variables in enabling the three formats to answer particular questions on the MSDS comprehensibility test.

Recommendations

1. Further investigation should be conducted at the national laboratory to discern why two-thirds of the union sample population studied rarely to almost never used MSDSs and whether such poor usage is reflective of the entire union work force.
2. More study should be conducted at the laboratory to determine why the 40-49 year age group scored significantly better using the OSHA type form as a reference than did the 50-59 year age group.
3. Efforts should be undertaken at the laboratory to address the needs of the one-fifth to the one-third union workers who indicated that MSDSs were difficult to understand, read, and confusing. Such efforts should include determining whether this percentage was pervasive with the total union workforce. Actions such as training, adjusting the average reading level, simplification of content and format should be considered.

4. Any future MSDS usage studies at the laboratory should be random in approach and include researchers and other employees that may come in contact with chemicals in their jobs.
5. Future research on the efficacy of the MSDS should include different ethnic groups as independent variables. Testing should be conducted in work populations that use English as a secondary language.
6. Similarly, as more senior citizens (ages greater than 65) are returning to the work force the effects of aging on the efficacy of the MSDS needs in-depth study. Age related depreciation on working memory and effect on MSDS efficacy is one example of what might be researched.
7. This study should be extended by examining on a national and international level the efficacy of the three MSDS formats studied applying the variables used in the study and those recommended for future research.
8. More in-depth research needs to be conducted to discover why the ICSC and OSHA type formats performed better than the CMA/ANSI Z400.1 structure in answering particular questions on the MSDS comprehensibility test. Variables such as jargon, fuzzy language, length of sentences, presentation of material, phraseology, and use of symbols should be tested for effect on MSDS efficacy.
9. Why one-third of the information provided on the three MSDSs was not diffused to the union workers studied needs further research.
10. Self-efficacy of the worker in relation to absorbing such scientific information as found on MSDS should be researched for effect on the efficacy of the MSDS.

11. Learning theories such as the Adoption Diffusion Innovation Theory, Social Cognitive Theory, and Value Expectancy Theory (Health Belief Model) should be considered in interpreting the efficacy of different MSDS formats.
12. Until further quantitative research to evaluate the efficacy of various MSDS formats is completed and considering the findings of this limited research, caution should be used in movement toward widespread adoption of the new CMA/ANSI Z400.1 structure. Efforts should be made to further field test the new format.

Implications

This study is similar to the study conducted by Kearney/Centaur Division, A. T. Kearney, Inc., in 1990-1991, under contract to OSHA, on the comprehensibility of Material Safety Data Sheets. Although the methodologies and many of the findings of the two studies are different, there are similarities.

The Kearney/Centaur study was non-random and descriptive in analysis. It involved testing ninety-one union workers from thirteen different manufacturing plants and one local trade union located in Maryland. All workers were open-book tested against four different randomly selected MSDSs averaging a twelfth grade readability. A questionnaire on demographics and other variables that might effect MSDS comprehension was administered. At the request of OSHA, the contractor of the study, no sophisticated statistical analyses were conducted. No pretesting and few controls were utilized in the study. The MSDS comprehensibility test used in the Kearney/Centaur study was also used in the

national laboratory study. The highest score achievable on the test was one hundred points for both studies. The following are comparative findings of the two research studies:

1. In both studies 69% of the workers were 30-49 years of age and both had 69-70% completing 9-12th grade and 30% completing 13-16th grade.
2. While 80% of those studied in the Kearney/Centaur evaluation had seen an MSDS before and 45% had been trained, 95% of the workers at the national laboratory had seen and been trained on MSDSs.
3. Where two-thirds of the Maryland workers had requested MSDSs, three-fourths of the laboratory sample population had done the same. Also 90% of the workers in Tennessee study who had requested MSDSs received them in hard copy compared to 60% in the Maryland study.
4. Similar to the findings of the Kearney/Centaur report where 80% of the workers had changed their work practices to safer methods as a result of the MSDS, the national laboratory study revealed that 79% of their study population had done likewise.
5. In the Maryland study almost half of the surveyed workers reported the MSDS as helpful while 90% of the laboratory workers similarly responded.
6. The two studies differed as to whether workers felt the MSDS to be confusing with the Kearney/Centaur study revealing two-thirds of the workers indicating yes versus one-third for the national laboratory.
7. Education was cited as having influenced the comprehensibility of MSDSs in the Kearney/Centaur study. Level of education did not influence the results of

the laboratory study in that readability was controlled to the 9th grade level.

8. The average test score achieved on the OSHA form and hybrids was 64 points and the ICSC format averaged 70.6 points in the Maryland study.

Comparatively total scores achieved in the national laboratory study on the OSHA type form MSDS was 67.2, ICSC 68.8, and CMA/ANSI Z400.1 structure 64.8 respectively. Although there was a rank order of finish in each study, in comparing the formats, both found that about one-third of the information available of the MSDS was diffused to the worker. The national laboratory study found that on the average one-third of the information was known or guessed by the worker prior to the introduction of the MSDS and about one-third of the required information was not imparted to the user. Both studies found that workplace characteristics did not appear to have impact on MSDS test scores.

9. As found in the laboratory study the highest average MSDS comprehensibility test score in the Maryland study was achieved by the ICSC format. In the Maryland study the ICSC ranged six to twenty-three percent higher as compared to one to six percent in the Tennessee study.

10. Both research studies gave supportive evidence, one descriptive and the other quantitative, that format does play a role in the efficacy of the MSDS. However, as shown in the national laboratory work force study, there was not a significant difference in the scores of the MSDS formats studied.

11. This study is timely and of national and international importance in that efforts are currently underway by OSHA, the International Standards Organization, and others to try to harmonize the MSDS format worldwide.

Although the study is limited to a small worker population in Tennessee, it produced supportive evidence that more research and efforts need to be directed toward developing an MSDS format that diffuses all of its information in a fully understandable manner. The formats and contents tested were only two-thirds of the way toward achieving such a goal.

12. Implications resulting from the MSDS acceptability inventory of the laboratory were that the laboratory union workers studied were well-trained on the MSDS, understood it, and accepted it as a viable document. However, there were lessor percentages of workers that needed to be better persuaded to use the MSDS. Possibly improvements in the form such as lowering the level of readability, format, and sentence simplification would improve their acceptability.

REFERENCES

REFERENCES

- Activator, T. S. (1990). Material Safety Data Sheets, A User Perspective. Professional Safety, pp 17-19.
- Ashford, A. N. (1977). Crisis in the Workplace: Occupational Disease and Injury. Cambridge, Massachusetts: Mit Press.
- Ashford, N. A. & Caldart, C. C. (1985). The "Right to Know" Toxics Information Transfer in the Workplace. Annual Review Public Health, 6, pp. 383-401.
- Bisby, J. A. & Coles, G. V. (1988). The Place of Material Safety Data Sheets in Work Hazard Control. Journal of Occupational Safety, Australia, New Zealand, 4(1), 57-64.
- Brown, M. S. (1984). The Right to Know: Hazard Information and the Control of Occupational Health Risks (Doctoral dissertation, Cornell University, 1984).
- Campbell, D. T. and Stanley, J. C. (1963). Experimental and Quasiexperimental Designs for Research. Chicago: Rand McNally.
- Campbell, S. L. (1992, June). A New Look for the MSDS. Occupational Health and Safety, 61, (6), pp. 62, 65-67.
- Carriere, R. (1985). Chemical Handling Training by MSDS Information Chart. Occupational Health and Safety, 55, (11), pp. 36-38.
- Chemical Manufacturers Association Secretariat for ANSI Z400.1. (1992) Draft Standard for the Preparation of Material Safety Data Sheets. Washington, D.C.: Author.
- Cherniak, M. J. (1992). MSDS Forms Give Necessary Information Only if Users Know How to Interpret Them. Occupational Health and Safety, 61, (10), pp. 78-80.
- Commission of the European Communities (1991). International Chemical Safety Cards Compiler's Guide, International Programme on Chemical Safety (UNEP/ILO/WHO). (Catalog Number: CD-NE-12561-EN-C). Brussels-Luxembourg, Belgium: European Communities Office Publication.
- Conover, J. W. (1971). Practical Nonparametric Statistics. New York. John Wiley & Sons.

- Craig, R. A., Featherstone, H. L., Frank, D. T., Klapper, L. S., and Rosen, L. M. (1995). Report on Exchanging Material Safety Data Sheets VIA Electronic Data Interchange: A Prototype, Logistics Management Institute. Mclean, Virginia.
- Cumming, J. B. (1989). Material Safety Data Sheets. Chemistry in Australia, p. 441.
- Darrow, F. L. (1928). The Story of Chemistry. New York, New York: Chartauqua Press.
- Department of Health and Human Services (1991). Healthy People 2000 National Health Promotion and Disease Prevention Objectives. (DHHS Publication No. 91-50213). Washington, D.C.; U.S. Government Printing Office.
- Department of Health and Human Services (1992). Making Health Communications Programs Work, A Planning Guide. (DHHS Publication No. 92-1493). Washington, C.C.; U.S. Government Printing Office.
- Emmet, E. A. (1988). The Dermatologist and the Right to Know. Dermatologic Clinics, 6(1), 21-26.
- Ensminger, J. T., Lu, P. Y. & Oen, C. (1988). Material Safety Data Sheets: The Martin Marietta Energy Systems, Inc., Experience. Journal of Hazardous Materials, 17, 259-268.
- Freimuth, V. S. (1979). Assessing the Readability of Health Education Messages. Public Health Reports, 94 (6), 568-570.
- General Accounting Office. (1992a) Occupation Safety and Health, Worksite Safety and Health Programs Show Promise. (GAO Publication HRD-92-15). Gaithersburg, MD: U.S. General Accounting Office Publications.
- General Accounting Office. (1992b). Occupational Safety & Health Employers' Experiences in Complying With the Hazard Communication Standard, (GAO Publication HRD-92-63BP. Gaithersburg, MD: U.S. General Accounting Office Publications.
- Genium Publishing Corporation. (1992). The MSDS Pocket Dictionary, (4th ed.). Schenectady, New York: Author.
- Glanz, K., Levis, F. M., and Rimer, B. K. (1990). Health Behavior and Health Education, Theory Research and Practice. San Francisco: Josse-Bass Inc.

- Goldberg, A. I., Dar-El, E. M., & Rubin, A. E. (1991). Threat Perception and the Readiness to Participate in Safety Programs. Journal of Organizational Behavior, 12, 109-122.
- Hadden, S. G. (1988). Community Right to Know: Results of Four Surveys. Working Paper 44, Austin, Texas. Lyndon B. Johnson School of Public Affairs.
- Hadden, S. G. (1989). Providing Citizens with Information About Health Effects of Hazardous Chemicals. Journal of Occupational Medicine, 31(6), 528-534.
- Hance, B. J. (1988). Improving Dialogue With Communities: A Risk Communication Manual for Government. Cook College, Rutgers University, Environmental Communication Research Program, New Jersey Agricultural Experiment Station.
- Hans, M. (1994). ANSI Standard Revises Look of Data Sheets. Safety and Health, 149, (2), p. 58-61.
- Hathaway, B. K. (1994). Understanding the Material Safety Data Sheet. American Association of Occupational Health Nurses Journal, 42, 6, pp. 290-295.
- Himmelstein, J. S. & Frumpkin, H. (1985). The Right to Know About Toxic Exposures. New England Journal of Medicine, 312(11), 687-690.
- Huck, S. W., Comeir, W. H., and Bounds, W. G. (1974). Reading Statistics and Research. New York: Harper and Row.
- Hughes, J. T. (1991). An Assessment of Training Needs for Worker Safety and Health Programs: Hazardous Waste Operations and Emergency Response, Applied Occupational and Environmental Hygiene, 6(2), 114-118.
- Ignatowski, A. J., and Weilles, E.D. (1995). Managing Material Safety Data Sheets World-Wide. American Industrial Hygiene Association Journal, 56(7), 698-705.
- Isaac, A.S., and Michael, W.B. (1995). Handbook in Research and Evaluation, 3rd Edition. San Diego, California: Edits.
- Kaplan, S. A. (1986). Development of Material Safety Data Sheets. Paper presented at the American Chemical Society Meeting, New York, New York.

- Kearney/Centaur Division of A. T. Kearney, Inc. (1991a). The Accuracy of Material Safety Data Sheets. Alexandria, VA.
- Kearney/Centaur Division of A. T. Kearney, Inc. (1991b). The Comprehensibility of Material Safety Data Sheets, Final Report. Alexandria, VA.
- Kolp, P., Sattler, B., Blaynew, M., and Sherwood, T. (1993). Comprehensibility of material Safety Data Sheets. American Journal of Industrial Medicine, 23, 135-141.
- Kolp, P., Williams, P., and Burtan, R. (1995). Assessment of the Accuracy of Material Safety Data Sheets. American Industrial Hygiene Association Journal, 56, (2), 178-183.
- Last, J. and Rosenau, M. (1980). Public Health and Preventive Medicine: New York, Appleton-Century-Crofts.
- Lerman, S. E., & Kipen, H. M. (1990). Material Safety Data Sheets. Archives of Internal Medicine, 150, 981-984.
- Long, J. R. (1992). Standard for Material Safety Data Sheets in the Offing. Chemical and Engineering News, 70(20), pp. 7-11.
- Lothar, S. (1984). Applied Statistics, A Handbook of Techniques, (2nd ed.). New York, New York: Springer-Verlag.
- Lu, C. W. & Moure-Eraso, R. (1993). Quality of Hazard Communication in the Manufacturing Industry: Evaluation of Material Safety Data Sheets. Paper presented at the American Industrial Hygiene Conference, New Orleans, Louisiana.
- Marousky, R. T. (1991). The Material Safety Data Sheet: A Guide to Chemical Safety in the OR. Today's OR Nurse, pp. 6-11.
- Mattheis, D. K. (1992). A National MSDS Repository. American Industrial Hygiene Association Journal, 53, 607-608.
- McLaughlin, G. H. (1969). SMOG Grading-New Readability Formula. Journal of Reading, pp. 639-646.
- McNeely, E. (1991). An Organizational Study of Hazard Communication. American Association of Occupational Health Nurses Journal, 38,(4), 165-173.

- Meninger, B. and Margolies, D. (1994, December). Safety Data Sheets Difficult to Understand. Kansas City Business Journal, 13, p. 55.
- Miller, G. H. (1986). Consistent, Accurate Data Needed for Preparing the MSDS. Occupational Health and Safety, pp. 31-33.
- Molinelli, R. P., Reale, M. J., and Freudenthal, R. I. (1992). Material Safety Data Sheets The Writers' Desk Reference. Boca Raton, Florida: Hill and Garnett Publishing, Inc.
- National Advisory Committee on Occupational Safety and Health, NACOSH, (1996). Report to OSHA on Hazard Communication, *
<<http://www.OSHA-SLC.gov/misc/WgFinal.html>>, February 1997.
- National Institute for Occupational Safety and Health. (1974). A Recommended Standard--An Identification System for Occupationally Hazardous Materials, (DHHS Publication No. PB 246-698). Washington, D.C.: U.S. Government Printing Office.
- National Safety Council. (1995). Accident Facts. Itasca, Illinois.
- Nelkin, D. & Brown, M. S. (1984). Workers at Risk. Chicago: University of Chicago Press.
- Niemeier, R. W. (1996). Joint Project is Creating Global Material Safety Data Sheets. Chemical and Engineering News, 74, (10), p. 18.
- Occupational Safety and Health Administration. (1976). Material Safety Data Sheet, (OSHA Publication No. 2265). Washington, D.C.: U.S. Government Printing Office.
- Occupational Safety and Health Administration. (1991a). General Industry Standards Code of Federal Regulations at 29 CFR 1910. (Office of the Federal Register National Archives and Records Administration). Washington, D.C.: U.S. Government Printing Office.
- Occupational Safety and Health Administration. (1991b). Hazard Communication Standard Code of Federal Regulations at 29 CFR 1910.1200. (Office of the Federal Register National Archives and Records Administration). Washington, D.C.: U.S. Government Printing Office.
- Orlick, D.C. (1978). Designing Sensible Surveys. Pleasantville, New York: Redgrave Publishing Company.

- Raniere, T. M. (1978). Chemical Hazard Identification--Our Need to Work Together. Occupational Health Nursing, pp. 19-21.
- Rogers, E. M. (1983). Diffusion of Innovations. New York: The Free Press.
- Rom, W. N. (1983). Environmental and Occupational Medicine. Boston: Little, Brown, and Company.
- Rosenstock, I. M., Strecher, V. J., & Becker, H. M. (1988). Social Learning Theory and the Health Belief Model. Health Education Quarterly, 15(2), 175-183.
- Samways, M. (1988). Functionally Illiterate Worker Also has "Right to Understand." Occupational Health and Safety, 57, (1).
- Santodonato, J. (1981). Design and Implementation of a Worker's Right to Know Program. American Industrial Hygiene Association Journal, 42, 666-670.
- SAS Institute, Inc. (1989). SAS/STAT Users' Guide, (4th ed.). 6(2), Cary, North Carolina.
- Singer, C. (1959). A Short History of Scientific Ideas to 1900. Oxford, England: Oxford University Press.
- Solomon, C. J. (1988). Understanding and Using the MSDS, American Association Occupational Health Nurses Journal, 36(9), 376-379.
- Stanevich, S. S. (1989). Guidelines for an Occupational Safety and Health Program. American Association of Occupational Health Nurses Journal, 37(6), 205-214.
- Strecher, V. J., Devellis, B. M., Becker, M. H., and Rosenstock, I. M. (1986). The Role of Self-Efficacy in Achieving Health Behavior Change. Health Education Quarterly, 13(1), pp. 73-91.
- Tan, K. K., Fishwick, N. G., Dickson, W. A. & Sykes, P. J. (1991). Does Training Reduce the Incidence of Industrial Hand Injuries? Journal of Hand Surgery, 16B(3), 323-326.
- Tompkins, N. C. (1991). Labor-Supported Committees Advocate Worker's Right to Understand an MSDS. Occupational Health and Safety, 60, (7), pp.23-25.

- Van Santen, R. A. (1989). Info Safe: Managing and Providing Information on Chemicals. Chemistry in Australia, pp. 440-441.
- Vartarian, H. A. (1990). Update on the OSHA Hazard Communication Standard. Paper presented at the AIChE Spring National Meeting, Orlando, Florida.
- West, A. S. (1991a). Material Safety Data Sheets--Effective in the Workplace? Paper presented at the American Chemical Society Meeting, New York, New York.
- West, A. S. (1991b). Worker Hazard Communications The Regulatory Framework, Plant/Operations Progress, 10(1), 13-16.

APPENDICES

APPENDICES

APPENDIX A. DEFINITION OF TERMS	127
APPENDIX B. APPROVAL LETTERS	134
B1. Approval Letter from ORNL	135
B2. Approval Letter from ORAU/ORNL Committee on Human Studies	136
APPENDIX C. MSDS EFFICACY INVENTORY	137
APPENDIX D: REVIEW PANEL	143
APPENDIX E: PRETEST AND POSTTEST: MEASUREMENT OF COMPREHENSIBILITY	145
E1. Pretest: Measurement of MSDS Comprehensibility	146
E6. Posttest: Measurement of MSDS Comprehensibility	150
APPENDIX F: TREATMENTS OSHA TYPE MSDS, CMA/ANSI Z400.1 MSDS, AND ICSC	154
F1. Treatment OSHA Type MSDS	155
F5. Treatments CMA/ANSI Z400.1MSDS	159
F13. Treatments ISCS MSDS	167
APPENDIX G: LETTER REQUESTING WORKER PARTICIPATION	169
APPENDIX H: PILOT RESULTS WORKER COMMENTS	171
H1. Pilot Results Worker Comments: MSDS Usage Inventory Critique	172
H7. Pilot Results Worker Comments: MSDS Test Questionnaire	177
H8. Pilot Results Worker Pretest and Posttest Scores	178
APPENDIX I: MSDS TEST ANSWER KEYS	179
I1. MSDS Test Answer Key OSHA Type Format	180
I5. MSDS Test Answer Key CMA/ANSI Z400.1 Format	183
I8. MSDS Test Answer Key ICSC Format	187
APPENDIX J: MSDS INVENTORY AND COMPREHENSIVE TEST RESULTS (RAW DATA)	191
J1. MSDS Comprehensibility Results	192
J5. MSDS Inventory Results	196

APPENDIX A
DEFINITION OF TERMS

APPENDIX A

Definition of Terms

ACGIH. American Conference of Governmental Industrial Hygienists. An organization of professionals in governmental agencies or educational institutions engaged in occupational safety and health programs.

Acute Exposure. Exposure of short duration, usually to relatively high concentrations or amounts of material. An acute exposure runs a comparatively short course.

Acute Health Effect. An adverse effect on a human or animal body, with effects showing up a short length of time after exposure.

ANSI. American National Standards Institute. A voluntary membership organization that develops consensus standards nationally and coordinates their development.

Boiling Point, BP. The temperature at which a liquid's vapor pressure equals the surrounding atmospheric pressure so that the liquid rapidly vaporizes.

Flammable materials with low BPs generally present special fire hazards [e.g., butane, BP=31°F (-.5°C); gasoline, BP=100°F (38°C)]. For mixtures, a range of temperature is given.

CFR. Code of Federal Regulations. A collection of the regulations established by law.

Chronic Exposure. Continuous or intermittent exposure extending over a long time period, usually to relatively low material amounts or concentrations.

Chronic Health Effect. An adverse effect on a human or animal body with symptoms that develop slowly over a long time period and persist or that recurs frequently.

Density. Mass/unit volume experienced in grams per cubic centimeter for solids and liquids and grams/liter for gases.

Diffusion. As operationally defined for the purpose of the study is the process by which an idea or innovation (safety information) is communicated over time to users of the MSDS. (Rogers, 1983).

DOT. US Department of Transportation. Regulates transportation of materials to protect the public as well as fire, law, and other emergency response personnel.

Efficacy. As operationally defined for purposes of this study is that quantifiable success or failure of the Material Safety Data Sheet (change agent) in diffusing information to users. This difference is measured in this study by gain scores, the difference is measured in this study by gain scores, the difference between pretest scores and posttest scores (mean 2 - mean1).

EPA, (US) Environmental Protection Agency. A federal agency with environmental protection regulatory and enforcement authority.

Evaporation Rate. The rate at which a material vaporizes (volatilizes, evaporates) from the liquid or solid state when compared to a known material's vaporization rate. An evaporation rate can be useful in evaluating a material's health and fire hazards.

Explosive Limits. See Flammable Limits.

Exposure Limits. The concentration in workplace air of a chemical deemed the maximum acceptable. This means that most workers can be exposed at given levels or lower without harmful effects. Exposure limits in common use are (1) TLV-TWA (threshold limit value / time-weighted average); (2) STEL (short-term exposure limit) or STEV (short-term exposure value); and (3) C (ceiling value).

Flammable Limits. The flammable limits of a gas or vapor can also be called the flammable range. Simply, the flammable limits of a gas or vapor are the percentages of gas or vapor capable of igniting or exploding.

Hazard Communication Standard. See OSH Act. Requires chemical manufacturers and importers to assess the hazards associated with the materials in their workplace (29 CFR 1910.1200).

LFL. See Lower Flammable Limit, Lower Explosive Limit.

Lower Explosive Limit, Lower Flammable Limit (LEL/LFL). The lower limit of flammability of a gas or vapor at ambient temperatures expressed in percent of gas or vapor by air volume. This limit is assumed constant for temperatures up to 120° C. Above this it should be decreased by a factor of 0.7 because with higher temperatures the material becomes more explosive.

MSDS. Material safety data sheet. OSHA has established guidelines for the descriptive data that should be concisely provided on a data sheet to serve as the basis for written hazard communication programs. The thrust of the

law is to have those who make, distribute, and use hazardous materials responsible for effective communication.

NIOSH. National Institute of Occupational Safety and Health as a federal agency. It conducts research on health and safety issues, tests, certifies respirators, and trains occupational safety and health professionals.

OSHA. The Occupational Safety and Health Administration. Part of the US Department of Labor.

OSH Act. The Occupational Safety and Health Act of 1970. Effective April 28, 1971. Public Law 91-596. Found at 29 CFR 1910, 1915, 1918, 1926. OSHA jurisdiction. The regulatory vehicle to ensure the safety and health of workers in firms larger than 10 employees. Its goal is to set standards of safety that prevent injury and illness among the workers. Regulating employee exposure and informing employees of the dangers of materials are key factors.

PEL. Permissible exposure limit. Established by OSHA and has the force of the law. Expressed as a time-weighted average (TWA) limit or as a ceiling exposure limit. A ceiling limit must never be exceeded instantaneously even if the TWA exposure limit is not violated.

Reactivity. A substance's tendency to undergo chemical reaction either by itself or with other materials with the release of energy.

Self - Efficacy. As operationally defined for the purpose of this study is the perceived confidence that one can successfully execute a behavior that is

required to produce outcomes, (Stretcher et al., 1986).

TLV. Threshold limit value. ACGIH established exposure guidelines for airborne concentrations of many chemical compounds. Refer to airborne concentrations of substances believed to represent conditions under which nearly all workers may be repeatedly exposed day after day without adverse effect.

TWA. Time-weighted average. The allowable time-weighted average concentration for a normal 8-hour workday or 40-hour week, to which nearly all workers may be repeatedly exposed day after day without adverse effect.

Upper Explosive Limit, Upper Flammable Limit. (UEL/ UFL). The highest concentration of a material in air that produces an explosion in fire or that ignites when it contacts an ignition source (high heat, electric arc, spark or flame). A higher concentration of the material in a smaller percentage of concentration in air is too rich to be ignited.

Vapor Density. The ratio of the mass of a vapor or gas to the mass of an equal volume of air. A molecular weight of gas divided by 29 equals the vapor density. Materials lighter than air have vapor densities of less than 1.0; materials heavier than air have vapor densities greater than 1.0. All vapors and gases mix with air, but lighter materials tend to rise and dissipate (unless confined).

Vapor Pressure. (Vapor pressure; vap p; v.p.) The pressure (often expressed in millimeters of mercury, mmHg) characteristic of any given temperature of a

vapor in equilibrium with its liquid or solid form. In conjunction with evaporation rates can determine how quickly a material becomes airborne.

APPENDIX B
APPROVAL LETTERS

OAK RIDGE NATIONAL LABORATORY
MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY

PHONE: (423) 576-5048
FAX: (423) 576-5070

EMAIL: phillipscc@ornl.gov

POST OFFICE BOX 2008
OAK RIDGE, TN 37831-6292

Date: May 8, 1996
To: J. H. Swanks
c: F. C. Kornegay, A. M. Shirley
From: *C. C. Phillips*
C. C. Phillips, 3550, MS-6292, 6-5048
Subject: Survey of Employee Understanding of Material Safety Data Sheets

I request approval to initiate a survey of employees, via a pre-test, treatment, and post-test mode, in an attempt to evaluate their understanding of Material Safety Data Sheets (MSDSs) in protecting themselves from various chemicals at ORNL. The resultant data will be utilized in a comparison study to determine the effectiveness of the current OSHA 174 MSDS format, the new Chemical Manufacturers Association/American National Standards Institute format and International Chemical Safety Card at imparting health and safety information to employees. A dual purpose will be served through this effort; that of providing data important in evaluation of MSDS training at ORNL and use of the data in support of a dissertation that I am completing toward a Doctor of Philosophy degree at University of Tennessee, with an emphasis in health and safety. Care will be taken to gain the approval of supervisors, employees, and unions involved, and at no time will LMER or ORNL be mentioned in name in the final dissertation. The final approach decided upon will be designed to be minimally disruptive to normal operations.

Upon receipt of your approval, I will finalize my proposal to my dissertation committee and commence a pilot study of the instruments to be used with the primary study to begin in the September-December time frame.

CCP:ses

Approved: _____

J. H. Swanks
J. H. Swanks

5/24/96

Date

Approval is conditional based upon the confidentiality of all participants and the company and that any interaction with bargaining unit employees will be coordinated through Gerald Watson of Employee Relations.

B1. Approval Letter From ORNL

Source: J. H. Swanks, Oak Ridge National Laboratory, May, 1996.



Oak Ridge
Associated
Universities

Post Office Box 117
Oak Ridge, Tennessee 37831-0117

MEMORANDUM

TO: Charles Phillips

FROM: Shirley A. Fry, M.B.; B.Ch. M.P.H. ^{SAF}
Chair, ORAU/ORNL Committee on Human Studies (MPA #1394)

DATE: September 30, 1996

RE: A COMPARISON OF THE COMPREHENSIBILITY OF DIFFERENT
MATERIAL SAFETY DATA SHEETS TO PROFESSIONAL AND
NONPROFESSIONAL WORKERS IN A NATIONAL LABORATORY

Your planned project was reviewed by the ORAU/ORNL Committee on Human Studies (CHS) at its meeting on August 29, 1996. The Committee concurred with the University of Tennessee Knoxville's IRB's that this project qualifies for exempt status under federal regulations. The Committee did recommend, however, that as a further means of assuring confidentiality of the individuals participating in the study, the survey sheets be mailed back to the investigators rather than handing them in upon completion.

Please be reminded that as the Principal Investigator on this project, you are responsible for immediately informing the Committee of any unplanned or unexpected project-related outcomes and/or any proposed changes in the project's protocol or consent form. Upon being notified of any such events or situations the Committee will review them and inform you whether or not the project may proceed. Please understand that in these circumstances you must have the Committee's reapproval of the project and consent form for continuation before proceeding.

If you have any questions, please contact Ms. Becky Hawkins, Secretary, CHS, at 576-1725.

cc. J. Jankovic
Dr. A. Shirley
Dr. Russ Knapp
CHS Files

B2. Approval Letter from ORAU/ORNL Committee on Human Studies

Source: S. A. Fry, ORAU/ORNL Committee of Human Studies, September, 1996.

APPENDIX C
MSDS EFFICACY INVENTORY

MSDS EFFICACY INVENTORY

Please take a couple of minutes to furnish some general information about your background and opinions on the Material Safety Data Sheet (MSDS). Please do not write your name or any identification on this questionnaire.

1. Gender? ☐ Female ☐ Male
2. What is your age group? Please check one:

 _____ less than or equal to 29
 _____ 30 - 39
 _____ 40 - 49
 _____ 50 - 59
 _____ 60 or greater
3. Please indicate the highest grade level you completed in elementary school, high school, or college:

 ☐ 1 - 4 ☐ 5 - 8 ☐ 9 - 12 ☐ 13 - 15 ☐ 16 or greater
4. How many years have you been working at ORNL?

 ☐ 0 - 10 ☐ 11 - 20 ☐ 21 - 30 ☐ greater than 30
5. What is your job classification? _____

6. a. Have you ever requested information from management on one or more chemicals with which you worked?

 Please check one: ☐ Yes ☐ No
 (If your answer is no, please stop and go to Question 7)

 b. If yes, was the information you requested given verbally, written materials, computer, or all three? Please check all that apply:

 ☐ Verbal ☐ Written ☐ Computer ☐ All three

 c. If written material, was it a material safety data sheet?

 Please check one: ☐ Yes ☐ No

 d. Did the information answer your questions?

 Please check one: ☐ Yes ☐ No

C.1. MSDS Efficacy Inventory

Source: Charles C. Phillips, "The Efficacy of Material Safety Data Sheets and Worker Acceptability." Doctoral Dissertation in Philosophy, the University of Tennessee, Knoxville, July, 1996.

7. How many chemicals do you use in your job/work place on a weekly basis? Please check one:
- ☐ None ☐ 1-5 ☐ 6-10 ☐ 10 or greater
8. I have received training on MSDSs. Please check one:
- ☐ In formal only ☐ on the job ☐ formal classroom and on the job ☐ never been trained
9. I have seen the following number of MSDSs in my workplace. Check one:
- ☐ 0 ☐ 1-5 ☐ 6-10 ☐ more than 10
10. I have changed to safer actions in my work as a result of reading MSDS information on chemicals?
- ☐ Strongly agree ☐ Agree ☐ No opinion ☐ Disagree ☐ Strongly disagree
11. MSDS sheets are available to me within the work shift at my work site.
- ☐ Strongly agree ☐ Agree ☐ No opinion ☐ Disagree ☐ Strongly disagree
12. To what extent do you think MSDS training provided to you was satisfactory in providing an understanding of the MSDS? Please check one:
- ☐ Very satisfactory ☐ Satisfactory ☐ No opinion ☐ Unsatisfactory ☐ Very unsatisfactory
13. To what extent do you think MSDS sheets are satisfactory in providing you information to protect yourself? Please check one:
- ☐ Very satisfactory ☐ Satisfactory ☐ No opinion ☐ Unsatisfactory ☐ Very unsatisfactory
14. How often do you use an MSDS when working with a chemical in your job? Please check one:
- ☐ Almost always ☐ Often ☐ Half of the time ☐ Rarely ☐ Almost never

C2. MSDS Efficacy Inventory (Continued)

Source: Phillips, 1996.

15. The Material Safety Reference Sheet (MSRS) is used in computers to locate the manufacturer's Material Safety Data Sheets (MSDS). All the information on the MSRS is collected for health and safety programs used to protect your health.

The Material Safety Reference Sheet (MSRS) should continue to be provided to the MSDS user.

☐ Strongly agree ☐ Agree ☐ No opinion ☐ Disagree ☐ Strongly disagree

- 16-22 I am provided MSDS's:
Please circle to what extent you agree.

		Strongly Agree		No Opinion	Disagree	Strongly disagree
		5	4	3	2	1
16.	During job planning	5	4	3	2	1
17.	Safety briefing at start of job	5	4	3	2	1
18.	When first introduced to chemical	5	4	3	2	1
19.	When a health/safety inspector comes around	5	4	3	2	1
20.	After job has finished	5	4	3	2	1
21.	After an accident or spill	5	4	3	2	1
22.	Never see one	5	4	3	2	1

C3. MSDS Efficacy Inventory (Continued)

Source: Phillips, 1996.

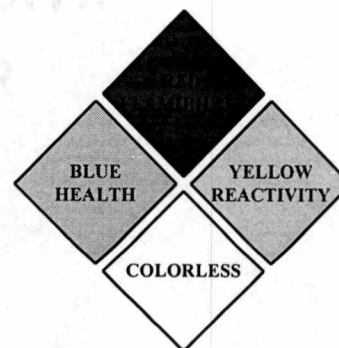
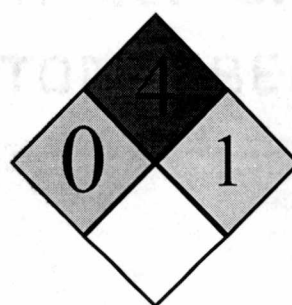
23-27. I would ask to see an MSDS:
Please circle to what extent you agree.

		Strongly agree	Agree	No opinion	Disagree	Strongly disagree
23.	During job planning	5	4	3	2	1
24.	During job safety briefing	5	4	3	2	1
25.	After job has started	5	4	3	2	1
26.	When first introduced to chemical	5	4	3	2	1
27.	After working with the chemical for some time	5	4	3	2	1

28-32. My opinion about the MSDS is:
Please circle to what extent you agree.

		Strongly agree	Agree	No opinion	Disagree	Strongly disagree
28.	Its words are difficult to understand	5	4	3	2	1
29.	It is easy to read	5	4	3	2	1
30.	It is not too long to read	5	4	3	2	1
31.	It has a confusing format	5	4	3	2	1
32.	Its symbols are easy to understand	5	4	3	2	1

Health Rating
4 = Extreme Health Hazard
3 = High Health Hazard
2 = Moderate Health Hazard
1 = Slight Health Hazard
0 = No Significant Health Hazard



C4. MSDS Efficacy Inventory (Continued)

Source: Phillips, 1996.

33-37. Regarding Health Hazard Rating numbers as shown above:

		Strongly agree	Agree	No opinion	Disagree	Strongly disagree
33.	They are useful	5	4	3	2	1
34.	They are confusing	5	4	3	2	1
35.	Written information would be better	5	4	3	2	1
36.	They should be on the MSDS	5	4	3	2	1
37.	They should be on labels	5	4	3	2	1

38-40. In my opinion:
Please circle the extent to which you agree.

		Strongly agree	Agree	No opinion	Disagree	Strongly disagree
38.	Chemicals I work with won't effect my health	5	4	3	2	1
39.	Chemicals can be a threat to your health	5	4	3	2	1
40.	This whole thing about chemical hazards is blown out of proportion	5	4	3	2	1

C5. MSDS Efficacy Inventory (Continued)

Source: Phillips, 1996.

APPENDIX D
REVIEW PANEL

Panel Members

1. Marwan Bader, MD, CIH
Industrial Hygienist
Lockheed Martin Energy Research Corporation
P. O. Box 2008
Oak Ridge, Tennessee 37831-6292
2. John D. Barncord
Environment, Safety, and Health Representative
Atomic Trades and Labor Council
Lockheed Martin Energy Research Corporation
P. O. Box 2008
Oak Ridge, Tennessee 37831-6292
3. Debbie Gray, MPH, CAOHC
Industrial Hygienist
Lockheed Martin Energy Research Corporation
P. O. Box 2008
Oak Ridge, Tennessee 37831-6292
4. David L. Kirby, CIH, CSP
Industrial Hygienist
Lockheed Martin Energy Research Corporation
P. O. Box 2008
Oak Ridge, Tennessee 37831-6292
5. Linda Pierce, CIH
Industrial Hygienist
Lockheed Martin Energy Research Corporation
P. O. Box 2008
Oak Ridge, Tennessee 37831-6292
6. Michael A. Sauri, MD, MPH&TM
Board Certified Occupational Medicine
Board Certified Preventive Medicine
Board Certified Internal Medicine
9715 Medical Center Drive
Suite 201
Rockville, Maryland 20850
7. Swati Wilson, DDS, MPH
Industrial Hygienist
Lockheed Martin Energy Research Corporation
P. O. Box 2008
Oak Ridge, Tennessee 37831-6292

APPENDIX E

**PRETEST AND POSTTEST: MEASUREMENT OF
COMPREHENSIBILITY**

QUESTIONNAIRE PRETEST

MEASUREMENT OF MSDS COMPREHENSIBILITY

Please answer all of the questions based on your knowledge about the chemical:

1. How can this chemical enter your body? (Check one or more.)
 - ☐ Breathing (lungs)
 - ☐ Eating/Drinking/Hand-to-mouth
 - ☐ Through the skin
 - ☐ Through the eyes
 - ☐ Do not know
2. What can be the immediate health effects caused by exposure to this chemical?
(Check one or more.)

☐ Nausea and/or vomiting	☐ Skin irritation
☐ Dizziness	☐ Loss of coordination
☐ Loss of consciousness	☐ Erratic behavior
☐ Burns	☐ Other (does not list)
☐ Breathing difficulty	☐ Do not know
☐ Mental confusion/forgetfulness	
3. What body systems may be immediately affected by an exposure?
(Check all correct answers.)
 - ☐ Nervous (brain and nerves)

E.1. PreTest: Measurement of MSDS Comprehensibility

Source: Kearney/Centaur Division of A. T. Kearney, Inc. (1991b). The Comprehensibility of Material Safety Data Sheets (Final Report). Alexandria, VA.

- ☐ Digestive (stomach and bowels)
 - ☐ Respiratory (breathing - nose/lungs)
 - ☐ Bladder/Kidneys
 - ☐ Sexual function/Reproduction
(Impotence) (pregnancy problems/sterility)
 - ☐ Muscles
 - ☐ Skeleton (bones)
 - ☐ Heart/Blood/Circulation
 - ☐ Eyes/Ears
 - ☐ Liver
 - ☐ Skin
 - ☐ Other (please list) _____
 - ☐ Do not know
4. Does this chemical have the potential to cause cancer?
- ☐ Yes ☐ No ☐ Do not know
5. What body system might be affected by a long-term exposure, over many years, to this chemical? (Check one or more.)
- ☐ Nervous (brain and nerves)
 - ☐ Digestive (stomach and bowels)
 - ☐ Respiratory (breathing - nose/lungs)
 - ☐ Bladder/Kidneys
 - ☐ Sexual function/Reproduction
(Impotence) (pregnancy problems/sterility)

E2 . PreTest: Measurement of MSDS Comprehensibility (Continued)

Source: Kearney/Centaur, 1991b.

- ☐ Muscles
- ☐ Skeleton (bones)
- ☐ Heart/Blood/Circulation
- ☐ Eyes/Ears
- ☐ Liver
- ☐ Skin
- ☐ Other (please list) _____
- ☐ Do not know

6. If you were working with this chemical, what type of personal protection would you expect to use? (Check all correct answers.)

- ☐ Respirator

Type respirator _____

- ☐ Protective clothing

Type clothing _____

- ☐ Eye protection

- ☐ Other (please list) _____

- ☐ Do not know if you or a co-worker has an exposure? _____

E3. PreTest: Measurement of MSDS Comprehensibility (Continued)

Source: Kearney/Centaur, 1991b.

7. What are the first aid procedures that you should follow if you or a co-worker has an exposure? _____

8. a. If there is a fire involving this chemical, what should you do?

- b. What precautions would avoid fires?

9. In the case of an accidental spill or leak, what should you do? _____

10. Who would you contact for more information about this chemical? _____

E4. PreTest: Measurement of MSDS Comprehensibility (Continued)

Source: Kearney/Centaur, 1991b.

QUESTIONNAIRE POST TEST

MEASUREMENT OF MSDS COMPREHENSIBILITY

Please answer all of the questions based on the information provided in the Material Safety Data Sheet (Refer to the MSDS):

1. Does this chemical have the potential to cause cancer?
☐ Yes ☐ No ☐ Does not say
2. What body systems may be immediately affected by an exposure?
(Check all correct answers.)
 - ☐ Nervous (brain and nerves)
 - ☐ Digestive (stomach and bowels)
 - ☐ Respiratory (breathing - nose/lungs)
 - ☐ Bladder/Kidneys
 - ☐ Sexual function/Reproduction
(Impotence) (pregnancy problems/sterility)
 - ☐ Muscles
 - ☐ Skeleton (bones)
 - ☐ Heart/Blood/Circulation
 - ☐ Eyes/Ears
 - ☐ Liver
 - ☐ Skin
 - ☐ Other (please list) _____
 - ☐ Does not say

E5. PostTest: Measurement of MSDS Comprehensibility

Source: Kearney/Centaur, 1991b.

3. a. If there is a fire involving this chemical, what does the Material Safety Data Sheet recommend?
- _____
- _____
- b. What precautions are suggested to avoid fires?
- _____
- _____
4. What body system might be affected by a long-term exposure, over many years, to this chemical? (Check one or more.)
- ☐ Nervous (brain and nerves)
 - ☐ Digestive (stomach and bowels)
 - ☐ Respiratory (breathing - nose/lungs)
 - ☐ Bladder/Kidneys
 - ☐ Sexual function/Reproduction
(Impotence) (pregnancy problems/sterility)
 - ☐ Muscles
 - ☐ Skeleton (bones)
 - ☐ Heart/Blood/Circulation
 - ☐ Eyes/Ears
 - ☐ Liver
 - ☐ Skin
 - ☐ Other (please list) _____
 - ☐ Do not know

E6. Posttest: Measurement of MSDS Comprehensibility (Continued)

Source: Kearney/Centaur, 1991b.

5. How can this chemical enter your body? (Check one or more.)
- ☐ Breathing (lungs)
 - ☐ Eating/Drinking/Hand-to-mouth
 - ☐ Through the skin
 - ☐ Through the eyes
 - ☐ Does not say
6. What are the first aid procedures that you should follow if you or a co-worker has an exposure?
- _____
- _____
- _____
7. If you were working with this chemical, what type of personal protection would you expect to use? (Check all correct answers.)
- ☐ Respirator
- Type respirator _____
- ☐ Protective clothing
- Type clothing _____
- ☐ Eye protection
 - ☐ Does not say any of these
8. In the case of an accidental spill or leak, what does the Material Safety Data Sheet suggest that you do? _____
- _____
- _____

E7. Posttest: Measurement of MSDS Comprehensibility (Continued)

Source: Kearney/Centaur, 1991b.

9. Who would you contact for more information about this chemical, based on the Material Safety Data Sheet? _____
- _____

10. What can be the immediate health effects caused by exposure to this chemical?

(Check one or more.) [10 pts.]

- | | |
|---|--|
| ☐ nausea and/or vomiting | ☐ Skin irritation |
| ☐ Dizziness | ☐ Loss of coordination |
| ☐ Loss of consciousness | ☐ Erratic behavior |
| ☐ Burns | ☐ Other (does not list) |
| ☐ Breathing difficulty | ☐ Does not say |
| ☐ Mental confusion/forgetfulness | |

E8. Posttest: Measurement of MSDS Comprehensibility (Continued)

Source: Kearney/Centaur, 1991b.

APPENDIX F

**TREATMENTS OSHA TYPE MSDS, CMA/ANSI Z400.1
MSDS, AND ICSC**

DATE 9/24/93

MATERIAL SAFETY DATA SHEET

PAGE 1

SECTION I - GENERAL INFORMATION

CATALOG NO R434105
(REORDER PRODUCT BY THIS NO.)
PRODUCT NAME 2-BUTANONE(METHYL ETHYL KETONE)
DATA SHEET NO R434105
2-BUTANONE
CHEMICAL NAME 2-BUTANONE
FORMULA C₄H₈O
CAS 78-93-3 NRTECS EL6475000
FORMULA WEIGHT 72
SUBJECT TO THE REPORTING REQUIREMENTS OF SARA TITLE III, SECTION 313.
SYNONYM METHYL ETHYLKETONE
MANUFACTURER SUPELCO INC. PHONE 814-359-3441
ADDRESS SUPELCO PARK, BELLEFONTE, PA 16823-0048

SECTION II - HAZARDOUS INGREDIENTS OF MIXTURES

CHEMICAL NAME
COMMON NAME - PERCENTAGE - CAS #
(FORMULA) - PEL(UNITS) - TLV(UNITS)
LD50 VALUE - CONDITIONS

N/A

SECTION III - PHYSICAL DATA

BOILING POINT 80 C MM MELTING POINT -87 C
VAPOR PRESSURE 70 MM C VAPOR DENSITY 0.805 C (AIR=1)
SPECIFIC GRAVITY N/A PERCENT VOLATILE BY VOLUME
WATER SOLUBILITY 27 EVAPORATION RATE N/A
APPEARANCE CLEAR COLORLESS LIQUID

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT 26 F FLAMMABLE LIMITS LEL 2.0 UEL

EXTINGUISHING MEDIA

CO₂
DRY CHEMICAL

SPECIAL FIRE FIGHTING PROCEDURES

WEAR SELF CONTAINED BREATHING APPARATUS WHEN FIGHTING A CHEMICAL FIRE.

UNUSUAL FIRE AND EXPLOSION HAZARDS

FLASHBACK ALONG VAPOR TRAIL MAY OCCUR.

SECTION V - HEALTH HAZARD DATA

LD50 N/A
PEL 200 PPM TLV 200 PPM

EMERGENCY AND FIRST AID PROCEDURES

EYES

FLUSH EYES WITH WATER FOR 15 MINUTES.

F.1. Treatment OSHA Type MSDS

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

SUPELCO, INC. SUPELCO PARK BELLEFONTE, PA 16823-0048

TWX 510-670-3600

DATE 9/24/93

MATERIAL SAFETY DATA SHEET

PAGE 2

CATALOG NO R434105 (REORDER PRODUCT BY THIS NO.)
PRODUCT NAME 2-BUTANONE(METHYL ETHYL KETONE)
DATA SHEET NO R434105
2-BUTANONE

SECTION V - HEALTH HAZARD DATA

* CONTINUED *

SKIN

FLUSH SKIN WITH LARGE VOLUMES OF WATER.
REMOVE CONTAMINATED CLOTHING.

INHALATION

IMMEDIATELY MOVE TO FRESH AIR.
GIVE OXYGEN IF BREATHING IS LABORED
IF BREATHING STOPS, GIVE ARTIFICIAL RESPIRATION
CONTACT A PHYSICIAN

INGESTION

NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON
NEVER TRY TO MAKE AN UNCONSCIOUS PERSON VOMIT
GIVE SYRUP OF IPECAC.

EFFECTS OF OVEREXPOSURE

HARMFUL IF ABSORBED THROUGH SKIN
HARMFUL IF INHALED
HARMFUL IF SWALLOWED
IRRITATES EYES
IRRITATES SKIN
DERMATITIS
IRRITATES NOSE AND THROAT
HEADACHE
NAUSEA
DIZZINESS
GASTROINTESTINAL DISTURBANCES
NARCOSIS

SECTION VI - REACTIVITY DATA

STABILITY STABLE.

CONDITIONS TO AVOID

N/A

INCOMPATIBILITY

STRONG BASES
OXIDIZING AGENTS
REDUCING AGENTS

F2. Treatment OSHA Type MSDS (Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

SUPELCO, INC. SUPELCO PARK BELLEFONTE, PA 16823-0048

TWX 510-670-3600

DATE 9/24/93

MATERIAL SAFETY DATA SHEET

PAGE. 3

CATALOG NO R434105 (REORDER PRODUCT BY THIS NO.)
PRODUCT NAME 2-BUTANONE(METHYL ETHYL KETONE)
DATA SHEET NO R434105
2-BUTANONE

SECTION VI - REACTIVITY DATA

* CONTINUED *

HAZARDOUS DECOMPOSITION PRODUCTS

N/A

HAZARDOUS POLYMERIZATION WILL NOT OCCUR.

CONDITIONS TO AVOID

N/A

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

TAKE UP WITH ABSORBENT MATERIAL.
VENTILATE AREA.
ELIMINATE ALL IGNITION SOURCES.
FLUSH AREA WITH WATER.

WASTE DISPOSAL METHOD

COMPLY WITH ALL APPLICABLE FEDERAL, STATE, OR LOCAL REGULATIONS

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (SPECIFIC TYPE)

WEAR NIOSH/OSHA APPROVED RESPIRATORY PROTECTION.

PROTECTIVE GLOVES

WEAR GLOVES.
WEAR IMPERVIOUS GLOVES.

EYE PROTECTION

WEAR PROTECTIVE GLASSES.
WEAR FACE SHIELD.

VENTILATION

USE ONLY IN EXHAUST HOOD.

F3. Treatment OSHA Type MSDS (Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

SUPELCO, INC. SUPELCO PARK BELLEFONTE, PA 16823-0048

TWX 510-670-3600

DATE 9/24/93

MATERIAL SAFETY DATA SHEET

PAGE 4

CATALOG NO R434105 (REORDER PRODUCT BY THIS NO.)
PRODUCT NAME 2-BUTANONE(METHYL ETHYL KETONE)
DATA SHEET NO R434105
2-BUTANONE

SECTION VIII - SPECIAL PROTECTION INFORMATION

* CONTINUED *

SPECIAL

N/A

OTHER PROTECTIVE EQUIPMENT

N/A

SECTION IX - SPECIAL PRECAUTIONS

STORAGE AND HANDLING

STORE IN SEALED CONTAINER IN FLAME CABINET.
KEEP AWAY FROM OXIDIZERS.
KEEP AWAY FROM BASES.
STORE IN DRY, WELL VENTILATED AREA.
KEEP AWAY FROM IGNITION SOURCES.

OTHER PRECAUTIONS

AVOID EYE OR SKIN CONTACT.
AVOID BREATHING VAPORS.

WHILE THE INFORMATION AND RECOMMENDATIONS SET FORTH HEREIN ARE BELIEVED TO BE ACCURATE AS OF THE DATE HEREOF, SUPELCO, INC. MAKES NO WARRANTY WITH RESPECT THERETO AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.

LAST REVISED 3/12/93

F4 . Treatment OSHA Type MSDS (Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.



ACC95495

****** MATERIAL SAFETY DATA SHEET ******

2-Butanone, 99+%
95495

****** SECTION 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION ******

MSDS Name: 2-Butanone, 99+%

Methyl ethyl ketone: MEK.
Company Identification: Acros Organics
Janssen Pharmaceuticaaan 3a
2440 Geel, Belgium
For information in North America, call: 800-ACROS-01
For information in Europe, call: 0032 (0) 14575211
For emergencies in the US, call CHEMTREC: 800-424-9300
For emergencies outside the US, call: 0032 (0) 14575299

****** SECTION 2 - COMPOSITION, INFORMATION ON INGREDIENTS ******

CAS#	Chemical Name	%	EINECS#
78-93-3	2-Butanone, 99+%	99+%	unlisted

Hazard Symbols: XI F
Risk Phrases: 11 36/37

****** SECTION 3 - HAZARDS IDENTIFICATION ******

EMERGENCY OVERVIEW

Appearance: Clear, colourless liquid. Flash Point: 22 F.
DANGER! EXTREMELY FLAMMABLE LIQUID. CAUSES RESPIRATORY TRACT IRRITATION. CAUSES SKIN IRRITATION. MAY CAUSE DIGESTIVE TRACT IRRITATION. MAY BE ABSORBED THROUGH THE SKIN. MAY CAUSE CENTRAL NERVOUS SYSTEM EFFECTS. CAUSES SEVERE EYE IRRITATION. MAY CAUSE DERMATITIS. MAY CAUSE FETAL EFFECTS.
Target Organs: Central nervous system, gastrointestinal system, skin.

Potential Health Effects

Eye:
Causes severe eye irritation.

Skin:
Causes skin irritation. Prolonged and/or repeated contact may cause defatting of the skin and dermatitis. May be absorbed through the skin.

Ingestion:
May cause gastrointestinal irritation with nausea, vomiting and

F5. Treatments CMA/ANSI Z400.1MSDS

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

diarrhea.

Inhalation:

Inhalation of high concentrations may cause central nervous system effects characterized by headache, dizziness, unconsciousness and coma. Causes respiratory tract irritation.

Chronic:

Chronic inhalation may cause effects similar to those of acute inhalation. Prolonged or repeated skin contact may cause defatting and dermatitis.

**** SECTION 4 - FIRST AID MEASURES ****

Eyes:

Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower lids. Get medical aid immediately. Do NOT allow victim to rub or keep eyes closed.

Skin:

Get medical aid. Immediately flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes.

Ingestion:

Do NOT induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Never give anything by mouth to an unconscious person. Get medical aid immediately.

Inhalation:

Get medical aid immediately. Remove from exposure to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.

Notes to Physician:

Treat symptomatically and supportively.
No specific antidote exists.

**** SECTION 5 - FIRE FIGHTING MEASURES ****

General Information:

As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Vapors can travel to a source of ignition and flash back.

Extinguishing Media:

In case of fire use water spray, dry chemical, carbon dioxide, or chemical foam.

Autoignition Temperature: 404_C (759.20_F)

Flash Point: 22_F (-5.56_C)

NFPA Rating: health-1; flammability-3; reactivity-0

Explosion Limits, Lower: 1.80
Upper: 11.5

**** SECTION 6 - ACCIDENTAL RELEASE MEASURES ****

General Information: Use proper personal protective equipment as indicated in Section 8.

Spills/Leaks:

Absorb spill with inert material, (e.g., dry sand or earth), then place into a chemical waste container. Avoid runoff into storm sewers and ditches which lead to waterways. Clean up spills immediately, observing precautions in the Protective Equipment section. Scoop up with a nonsparking tool, then place into a suitable container for disposal. Remove all sources of ignition.

**** SECTION 7 - HANDLING and STORAGE ****

Handling:

F6. Treatments CMA/ANSI Z400.1MSDS(Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

Wash thoroughly after handling. Wash hands before eating. Use only in a well ventilated area. Use spark-proof tools and explosion proof equipment. Avoid breathing dust, vapor, mist, or gas. Do not get on skin or in eyes. Do not ingest or inhale.

Storage:

Store in a cool, dry place. Store in a tightly closed container.

****** SECTION 8 - EXPOSURE CONTROLS, PERSONAL PROTECTION ******

Engineering Controls:

Use process enclosure, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits.

Exposure Limits			
Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
2-Butanone, 99+%	200 ppm ; 590	200 ppm TWA; 590	200 ppm TWA; 590
	mg/m3; 300 ppm	mg/m3 TWA; 300	mg/m3 TWA
	STEL; 885 mg/m3	ppm STEL; 885	
	STEL	mg/m3 STEL	

OSHA Vacated PELs:

2-Butanone, 99+%:

200 ppm TWA; 590 mg/m3 TWA; 300 ppm STEL; 885 mg/m3 STEL

Personal Protective Equipment

Eyes:

Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133.

Skin:

Wear appropriate protective gloves to prevent skin exposure.

Clothing:

Wear appropriate protective clothing to prevent skin exposure.

Respirators:

Follow the OSHA respirator regulations found in 29CFR 1010.134. Always use a NIOSH-approved respirator when necessary.

****** SECTION 9 - PHYSICAL AND CHEMICAL PROPERTIES ******

Physical State:	Liquid
Appearance:	Clear, colourless liquid.
Odor:	Sweet, minty, acetone-like.
pH:	Not available.
Vapor Pressure:	105 mbar @ 20 C
Vapor Density:	2.5
Evaporation Rate:	2.7 (Ether=1)
Viscosity:	0.42 mPa @ 15 C
Boiling Point:	80.0 C
Freezing/Melting Point:	-87.0 C
Decomposition Temperature:	Not available.
Solubility:	In water: 290 g/l (20 C)
Specific Gravity/Density:	0.8050
Molecular Formula:	C4H8O
Molecular Weight:	72.0554

F7. Treatments CMA/ANSI Z400.1MSDS Type of Format (Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

**** SECTION 10 - STABILITY AND REACTIVITY ****

Chemical Stability:

Unstable.

Conditions to Avoid:

Mechanical shock, incompatible materials, ignition sources, excess heat.

Incompatibilities with Other Materials:

Amines, ammonia, caustics, chloroform + alkali, chlorosulfonic acid, copper, hydrogen peroxide + nitric acid, inorganic acids, isocyanates, potassium-t-butoxide, 2-propanol, pyridines, strong oxidizers, fuming sulfuric acid.

Hazardous Decomposition Products:

Carbon monoxide, carbon dioxide.

Hazardous Polymerization: Will not occur.

**** SECTION 11 - TOXICOLOGICAL INFORMATION ****

RTECS#:

CAS# 78-93-3: EL6475000

LD50/LC50:

CAS# 78-93-3: Inhalation, mouse: LC50 = 40 gm/m3/2H; Inhalation, rat: LC50 = 23500 mg/m3/8H; Oral, mouse: LD50 = 4050 mg/kg; Oral, rat: LD50 = 2737 mg/kg; Skin, rabbit: LD50 = 6480 mg/kg.

Carcinogenicity:

2-Butanone, 99+8 -

Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.

Epidemiology:

No information available.

Teratogenicity:

Embryo or Fetus: fetotoxicity, ihl-rat TCLo:1000 ppm. Specific Developmental Abnormalities: craniofacial and urogenital, ihl-rat TCLo:3000 ppm/7H; musculoskeletal, ihl-rat TCLo:1000 ppm.

Reproductive Effects:

No information available.

Neurotoxicity:

No information available.

Mutagenicity:

sln-smc 33800 ppm

Other Studies:

None.

**** SECTION 12 - ECOLOGICAL INFORMATION ****

Ecotoxicity:

Fathead minnow LC50:3220 mg/L/96H Bluegill TLM:5640 - 1690 mg/L/24 (96H)

Environmental Fate:

Substance evaporates in water with T1/2= 3D (rivers) to 12D (lakes). Substance is not expected to bioconcentrate in aquatic organisms.

Physical/Chemical:

Substance photodegrades in air with T1/2 = 2.3 days.

Other:

None.

**** SECTION 13 - DISPOSAL CONSIDERATIONS ****

Dispose of in a manner consistent with federal, state, and local regulations.

RCRA D-Series Maximum Concentration of Contaminants: waste number D035; regulate

RCRA D-Series Chronic Toxicity Reference Levels: chronic toxicity reference level

RCRA F-Series: Not listed.

RCRA P-Series: Not listed.

RCRA U-Series: waste number U159 (Ignitable waste; Toxic waste)

F8. Treatments CMA/ANSI Z400.1MSDS Type of Format (Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

This material is banned from land disposal according to RCRA.

**** SECTION 14 - TRANSPORT INFORMATION ****

US DOT
Shipping Name: ETHYL METHYL KETONE
Hazard Class: 3
UN Number: UN1193
Packing Group: II

IMO
Shipping Name: ETHYL METHYL KETONE
Hazard Class: 3.2
UN Number: 1193
Packing Group: 2

IATA
Shipping Name: METHYL ETHYL KETONE
Hazard Class: 3
UN Number: 1193
Packing Group: 2

RID/ADR
Shipping Name: ETHYL METHYL KETONE (METHYL ETHYL KETONE)
Dangerous Goods Code: 3(3B)
UN Number: 1193
Canadian TDG
No information available.

**** SECTION 15 - REGULATORY INFORMATION ****

A. Federal

TSCA

CAS# 78-93-3 is listed on the TSCA inventory.
Health & Safety Reporting List
CAS# 78-93-3: Effective Date: October 4, 1982
Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.
Section 12b
None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.

CERCLA/SARA

Section 302 (RQ)
None of the chemicals in this material have an RQ.
Section 302 (TPQ)
None of the chemicals in this product have a TPQ.
SARA Codes
CAS # 78-93-3: acute, flammable.
Section 313
This chemical is not at a high enough concentration to be reportable under Section 313.
No chemicals are reportable under Section 313.

Clean Air Act:

CAS# 78-93-3 is listed as a hazardous air pollutant (HAP).
This material does not contain any Class 1 Ozone depleters.
This material does not contain any Class 2 Ozone depleters.

Clean Water Act:

None of the chemicals in this product are listed as Hazardous Substances under the CWA.
None of the chemicals in this product are listed as Priority Pollutants under the CWA.
None of the chemicals in this product are listed as Toxic Pollutants under the CWA.

OSHA:

None of the chemicals in this product are considered highly hazardous

F9. Treatments CMA/ANSI Z400.1 MSDS Type of Format (Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

by OSHA.

B. State
 2-Butanone, 99+% can be found on the following state right to know lists: California, New Jersey, Florida, Pennsylvania, Minnesota, Massachusetts.
 California No Significant Risk Level:
 None of the chemicals in this product are listed.

C. International
 Canada
 CAS# 78-93-3 is listed on Canada's DSL/NDSL List.
 CAS# 78-93-3 is listed on Canada's Ingredient Disclosure List.
 European Labeling in Accordance with EC Directives
 Hazard Symbols: XI F
 Risk Phrases:
 R 11 Highly flammable.
 R 36/37 Irritating to eyes and respiratory system.
 Safety Phrases:
 S 16 Keep away from sources of ignition - No smoking.
 S 25 Avoid contact with eyes.
 S 33 Take precautionary measures against static discharges.
 S 9 Keep container in a well-ventilated place.

Exposure Limits:
 OEL-AUSTRALIA:TWA 150 ppm (445 mg/m3);STEL 300 ppm (890 mg/m3). OEL-AUSTRALIA:TWA 200 ppm (590 mg/m3). OEL-BELGIUM:TWA 200 ppm (590 mg/m3);STEL 300 ppm (885 mg/m3). OEL-DENMARK:TWA 100 ppm (290 mg/m3);Skin. OEL-FINLAND:TWA 150 ppm (440 mg/m3);STEL 190 ppm;Skin. OEL-FRANCE:TWA 200 ppm (600 mg/m3);Skin. OEL-GERMANY:TWA 200 ppm (590 mg/m3). OEL-HUNGARY:TWA 200 mg/m3;STEL 600 mg/m3. OEL-INDIA:TWA 200 ppm (590 mg/m3);STEL 300 ppm (885 mg/m3). OEL-JAPAN:TWA 200 ppm (590 mg/m3). OEL-THE NETHERLANDS:TWA 200 ppm (590 mg/m3). OEL-THE PHILIPPINES:TWA 200 ppm (590 mg/m3). OEL-POLAND:TWA 200 mg/m3. OEL-RUSSIA:TWA 200 ppm;STEL 200 mg/m3. OEL-SWEDEN:TWA 50 ppm (150 mg/m3);STEL 100 ppm (300 mg/m3). OEL-SWITZERLAND:TWA 200 ppm (590 mg/m3);STEL 400 ppm. OEL-TURKEY:TWA 200 ppm (590 mg/m3). OEL-UNITED KINGDOM:TWA 200 ppm (590 mg/m3);STEL 300 ppm. OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA check ACGIH TLV. OEL IN NEW ZEALAND, SINGAPORE, VIETNAM check ACGI TLV

**** SECTION 16 - ADDITIONAL INFORMATION ****

Additional Information:
 Added NFPA codes to Section 5. Added SARA classifications to Section 15.
 Section 3, Emer Overview, added "DANGER!..".
 Section 3, Emer Overview, added "EXTREMELY FLAMMABLE LIQUID...".
 Section 3, Emer Overview, added "CAUSES RESPIRATORY TRACT IRRITATION...".
 Section 3, Emer Overview, added "CAUSES SKIN IRRITATION...".
 Section 3, Emer Overview, added "MAY CAUSE DIGESTIVE TRACT IRRITATION...".
 Section 3, Emer Overview, added "CAUSES SEVERE EYE IRRITATION...".
 Section 3, Emer Overview, added "MAY BE ABSORBED THROUGH THE SKIN...".
 Section 3, Emer Overview, added "MAY CAUSE FETAL EFFECTS...".
 Section 3, Emer Overview, added "MAY CAUSE DERMATITIS...".
 Section 3, Emer Overview, added "MAY CAUSE CENTRAL NERVOUS SYSTEM EFFECTS...".
 Section 3, Eye Effects, added "Causes severe eye irritation...".
 Section 3, Skin Effects, added "Prolonged and/or repeated contact may...".
 Section 3, Skin Effects, added "May be absorbed through the skin...".

F10. Treatments CMA/ANSI Z400.1MSDS Type of Format (Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

Section 3, Skin Effects, added "Causes skin irritation...".
 Section 3, Inhalation Effects, added "Inhalation of high concentrations m...".
 Section 3, Inhalation Effects, added "Causes respiratory tract irritation...".
 Section 3, Ingestion Effects, added "May cause gastrointestinal irritati...".
 Section 3, Chronic Effects, added "Chronic inhalation may cause effect...".
 Section 3, Chronic Effects, added "Prolonged or repeated skin contact...".
 Section 4, Eye First Aid, added "Get medical aid immediately...".
 Section 4, Eye First Aid, added "Do NOT allow victim to rub or keep...".
 Section 4, Eye First Aid, added "Immediately flush eyes with plenty...".
 Section 4, Skin First Aid, added "Get medical aid...".
 Section 4, Skin First Aid, added "Immediately flush skin with plenty...".
 Section 4, Inhalation First Aid, added "Get medical aid immediately...".
 Section 4, Inhalation First Aid, added "Remove from exposure to fresh air i...".
 Section 4, Inhalation First Aid, added "If not breathing, give artificial r...".
 Section 4, Inhalation First Aid, added "If breathing is difficult, give oxy...".
 Section 4, Ingestion First Aid, added "Do NOT induce vomiting...".
 Section 4, Ingestion First Aid, added "If victim is conscious and alert, g...".
 Section 4, Ingestion First Aid, added "Get medical aid immediately..".
 Section 4, Ingestion First Aid, added "Never give anything by mouth to an...".
 Section 5, Extinguishing Media, added "In case of fire use water spr ay, dr...".
 Section 5, General Firefighting, added "As in any fire, wear a self-contain...".
 Section 5, General Firefighting, added "Vapors can travel to a source of ig...".
 Section 6, Spills/Leaks, added "Absorb spill with inert material, (. . .".
 Section 6, Spills/Leaks, added "Avoid runoff into storm sewers and..".
 Section 6, Spills/Leaks, added "Remove all sources of ignition...".
 Section 6, Spills/Leaks, added "Scoop up with a nonsparking tool, t..".
 Section 6, Spills/Leaks, added "Clean up spills immediately, observ..".
 Section 7, Handling, added "Avoid breathing dust, vapor, mist,..".
 Section 7, Handling, added "Use spark-proof tools and explosion...".
 Section 7, Handling, added "Wash thoroughly after handling...".
 Section 7, Handling, added "Wash hands before eating...".
 Section 7, Handling, added "Use only in a well ventilated area...".
 Section 7, Handling, added "Do not get on skin or in eyes...".
 Section 7, Handling, added "Do not ingest or inhale...".
 Section 7, Storage, added "Store in a tightly closed container..".
 Section 7, Storage, added "Store in a cool, dry place...".
 Section 8, Engin. Controls, added "Use process enclosure, local exhaust...".
 Section 8, Eye Protection, added "Wear appropriate protective eyeglass...".
 Section 8, Skin Protection, added "Wear appropriate protective glove

F11. Treatments CMA/ANSI Z400.1MSDS Type of Format (Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

s...".
 Section 8, Clothing, added "Wear appropriate protective clothin..".
 Section 8, Respirators, added "Follow the OSHA respirator regulati..
 ".
 Section 9, Physical Properties has changed.
 Section 10, Stability, added "Unstable...".
 Section 10, Condit. to Avoid, added "ignition sources...".
 Section 10, Condit. to Avoid, added "excess heat...".
 Section 10, Condit. to Avoid, added "mechanical shock...".
 Section 10, Condit. to Avoid, added "incompatible materials...".
 Section 10, Decomposition Prod., added "carbon monoxide...".
 Section 10, Decomposition Prod., added "carbon dioxide...".
 Section 10, Incompatibilities has changed.
 Section 11, Epidemiology has changed.
 Section 11, Neurotoxicity has changed.
 Section 11, Teratogenicity has changed.
 MSDS Creation Date: 10/18/1995 Revision Date: 3/04/1996

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no way shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.



F12. Treatments CMA/ANSI Z400.1 MSDS Type of Format (Continued)

Source: Lockheed Martin Energy Research Corporation (LMERC) Material Safety Database, August 1996.

METHYL ETHYL KETONE		ICSC: 0179	
CAS # 79-53-3 RTECS # EL6475000 ICSC # 0179 UN # 1153; 1232 EC # 606-002-00-3		2-Butanone Methylpropanone MEK C_4H_8O Molecular mass: 72.1	
HAZARD SYMBOLS <i>Consult national legislation</i>			
TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Highly flammable.	NO open flames, NO sparks, and NO smoking.	Alcohol-resistant foam, powder, carbon dioxide, NO water.
EXPLOSION	Vapour/air mixtures are explosive.	Closed system, ventilation, explosion-proof electrical equipment and lighting. Do NOT use compressed air for filling, discharging, or handling.	In case of fire: keep drums, etc., cool by spraying with water.
EXPOSURE		PREVENT GENERATION OF MISTS:	
☐ Inhalation	Cough, dizziness, dullness, headache, nausea, shortness of breath, vomiting.	Ventilation, local exhaust, or breathing protection.	Fresh air, rest, and refer for medical attention.
☐ Skin	MAY BE ABSORBED! Redness.	Protective gloves, protective clothing.	Remove contaminated clothes, rinse skin with plenty of water or shower.
☐ Eyes	Redness, pain.	Face shield or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
☐ Ingestion	Abdominal cramps, confusion, dizziness, headache, nausea, vomiting.	Do not eat, drink, or smoke during work.	Rinse mouth, give plenty of water to drink, and refer for medical attention.
SPILLAGE DISPOSAL	STORAGE		PACKAGING & LABELLING
Consult an expert (waste combustion), collect leaking and spilled liquid in sealable containers as far as possible, absorb remaining liquid in sand or inert absorbent and remove to safe place, do NOT wash away into sewer, (extra personal protection: self-contained breathing apparatus).	Fireproof, separated from strong oxidants, well closed, cool, keep in a well-ventilated room.		UN Haz Class: 3 UN Pack Group: II FURTHER INFORMATION ON LABELLING: <i>Consult national legislation</i>
ADDITIONAL INFORMATION			
SEE IMPORTANT INFORMATION ON BACK			

F13. Treatments ISCS MSDS

Source: Commission of European Communities (1991), International Chemical Safety Card Compilers Guide. Brussels-Luxembourg, Belgium: European Communities Office Publication.

I M P O R T A N T D A T A	PHYSICAL STATE; APPEARANCE COLOURLESS LIQUID, WITH CHARACTERISTIC ODOUR. PHYSICAL DANGERS: The vapour is heavier than air and may travel along the ground; distant ignition possible. CHEMICAL DANGERS: On combustion, forms toxic gases. Reacts violently with strong oxidants, causing fire and explosion hazard. OCCUPATIONAL EXPOSURE LIMITS: TLV: 200 ppm; 590 mg/m³ (as TWA); 300 ppm; 885 mg/m³ (as STEL) (ACGIH 1988-1990). ROUTES OF EXPOSURE: The substance can be absorbed into the body by inhalation and through the skin, and by ingestion. INHALATION RISK: A harmful contamination of the air can be reached rather quickly on evaporation of this substance at 20°C. EFFECTS OF SHORT-TERM EXPOSURE: The substance irritates the eyes, the skin, and the respiratory tract. The substance may cause effects on the central nervous system, resulting in narcotic effects, lowering of blood pressure, and effects to the heart and respiration. EFFECTS OF LONG-TERM OR REPEATED EXPOSURE: The liquid defats the skin.				
PHYSICAL PROPERTIES	Boiling point at 101.3 kPa: 80°C Melting point: -86°C Relative density (water = 1): 0.803 Solubility in water, g/100 ml at 20°C: 29 Vapour pressure, kPa at 20°C: 10.5 Relative vapour density (air = 1): 2.41 Flash point: -6°C (o.c.) Auto-ignition temperature: 505°C Explosive limits, vol % in air: 1.5-11.5 Octanol/water partition coefficient as log Pow: 0.29				
ENVIRONMENTAL DATA	This substance may be hazardous to the environment: special attention should be given to water.				
NOTES					
The odour warning when the exposure limit value is exceeded is insufficient. Transport Emergency Card: TEC (R)- 68 NFPA Code: H 1 ; F 3 ; R 0					
<table border="1"> <thead> <tr> <th colspan="2" data-bbox="582 1049 817 1070">ADDITIONAL INFORMATION</th></tr> </thead> <tbody> <tr> <td data-bbox="281 1070 705 1432"></td><td data-bbox="705 1070 1096 1432"></td></tr> </tbody> </table>		ADDITIONAL INFORMATION			
ADDITIONAL INFORMATION					
ICSC: 0179	© CEC, IPCS, 1991 METHYL ETHYL KETONE				

F14. Treatments ISCS MSDS(Continued)

Source: Commission of European Communities, (1991).

APPENDIX G
LETTER REQUESTING WORKER PARTICIPATION

Dear Co-Worker:

OSHP is concerned about your health and safety. We also want to insure that the Material Safety Data Sheet (MSDS) provides you with understandable and sufficient information to protect you from harmful exposures to chemicals when you do your job. As a result, you have been randomly selected to participate in a one hour study on how well the form provides you with information you need to protect yourself. You will be provided a series of questions. Please do not identify yourself in any way on the questionnaires. We will reveal no individual response and will report all data in group form. Completion of the questionnaire provided should take no more than one hour. Your return of all questionnaires is your consent to participate in this study.

Though your selection was random, your opinion is very important. Please complete all questionnaires. They will be collected during the session.

Your presence is voluntary, however, as an incentive for your participation you will be provided coffee and cookies, and if you complete the session, a safety award will be given to you. More importantly, you will have participated in a study that will help us help you and others.

Instructions for completing the questionnaires will be given verbally. Should you have any questions regarding this research, please contact me at 576-5048.

Charles C. Phillips

G.1. Letter Requesting Worker Participation

Source: Charles C. Phillips, "The Efficacy of Material Safety Data Sheets and Worker Acceptability." Doctoral Dissertation in Philosophy, The University of Tennessee, Knoxville, July, 1996.

APPENDIX H
PILOT RESULTS WORKER COMMENTS

SUMMARY

MSDS USAGE INVENTORY CRITIQUE

1. Easy to Understand. Yes 18 No 2
If not, why not?
 1. Thought I should stop at # 9, confusing
 2. Not enough choices or answers not all questions are yes, no or no opinion.
 3. Only section II, health hazard, sampling, and effects are important to H&S.
2. Does it ask appropriate questions? Yes 17 No 1 Some 1
3. Is it too long? Yes 2 No 17 No opinion 1
4. How would you improve this questionnaire?
Allow responses for employees that use www.
Allow responses for employees that don't use MSDS.
Increase choices of answers.
Place numerical heading at top of continuing page.
Question nine instructions to continue to question 10.
Put a " does not apply box" for people that question 10 does not apply to.
It might be good to find out what kind of conditions specifically affect comprehension of MSDS - language, availability, length, use of chemical terms.
Have more questions for people who rarely use MSDSs, but have opinions on their usage.
Amount of chemical wasn't discussed. PPE and other considerations would depend on amounts of usage.
5. Were instructions adequate? Yes 17 No 2 No response 1
If not, explain:
Needed more explanation as to which questions were appropriate to answer.
Also, I wonder how to answer when I use the www for MSDS information.
Purpose of study should be explained.
Question #9 needs to be rewritten.
6. Comments:
If a person doesn't use chemicals, you would need an N/A category.
Some questions are wordy, #18.
Word more generic for all categories.
#16 has no choice parameters.
#3 parameters very confusing.
#33 and 34, do these people know the law?
What information is being assessed?

H.1. Pilot Results Worker Comments: MSDS Usage Inventory Critique

Source: As tabulated, 1996.

MSDS EFFICACY INVENTORY

Please take a couple of minutes to furnish some general information about your background and opinions on the Material Safety Data Sheet (MSDS). Please do not write your name or any identification on this questionnaire.

1. Gender? ☐ Female(13) ☐ Male(7)
2. What is your age group? Please check one:
☐ less than 30 (1)
☐ 30 - 39 (6)
☐ 40 - 49 (10)
☐ 50 - 59 (2)
☐ 60 or greater (1)
3. Please indicate the highest grade level you completed in elementary school, high school, or college:
☐ (0) 1 - 4 ☐ (0) 5 - 8 ☐ (2) 9 - 12 ☐ (7) 13 - 15 ☐ (11) 16 or greater
4. How many years have you been working at ORNL?
☐ (19) 0 - 10 ☐ (1) 11-20 ☐ (0) 21 - 30 ☐ (0) greater than 30
5. What is your job classification?
Industrial hygienist (6) Industrial hygiene technician (7)
Secretary (2) Safety specialist (1)
Research assistant (1) No response (3)
6. I have been trained to use an MSDS? Check one.
☐ (14) Yes ☐ (5) No ☐ (1) Do not know
7. Have you found it difficult to understand an MSDS? Check one.
☐ (6) Yes ☐ (9) No ☐ (5) No opinion
8. Have you altered your work habits as a result of obtaining MSDS information on a chemical?
☐ (8) Yes ☐ (11) No ☐ (1) Do not know

H2. Pilot Results Worker Comments: MSDS Usage Inventory (Continued)

Source: As tabulated, 1996.

If yes, please indicate how you have changed you habits:

9. a. Have you ever requested information from management on one or more chemicals with which you worked? Check one:

(5) (14) (1)
☐ Yes ☐ No ☐ NA

(If your answer is no, please stop and go to Question 10)

- b. If yes, was the information you requested given verbally, written materials, computer, or all three? Please check all that apply:

(3) (1) (3) (0)
☐ Verbal ☐ Written ☐ Computer ☐ All three

- c. If written material, was it a material safety data sheet?

(2) (3) (1)
Please check one: ☐ Yes ☐ No No answer

- d. Did the information answer your questions?

(4) (1)
Please check one: ☐ Yes ☐ No

10. MSDS sheets are available to me within the work shift at my work site.

(9) (6) (No answers - 5)
☐ Strongly agree ☐ Agree ☐ No opinion ☐ Disagree ☐ Strongly disagree

- 11-16 I am provided MSDS's:
Please circle to what extent you agree.

		Strongly Agree	No opinion	Disagree	Strongly disagree
11.	During job planning	5 (2) NA-4	4 (4)	3 (7)	2 (1)
12.	Safety briefing at start of job	5 (0) no answer 4	4 (2)	3 (8)	2 (5)
13.	When a health/safety inspector comes around	5 (1) no answer 4	4	3 (10)	2 (4)
14.	After job has finished	5 no answer 4	4	3 (8)	2 (5)
15.	After an accident or spill	5 (1) NA - 4	4 (1)	3 (9)	2 (4)
16.	Never see one	5 no answer 6	4 (2)	3 (7)	2 (3)

H3. Pilot Results Worker Comments: MSDS Usage Inventory (Continued)

Source: As tabulated, 1996.

17. How many chemicals do you use in your job/work place on a weekly basis? Please check one:
- ☐ None (6) ☐ 1-10 (8) ☐ 11-20 (1) ☐ 21 or greater
18. To what extent do you think MSDS training provided to you was satisfactory in providing an understanding of the MSDS? Check one:
- (5) (7) (4)
- ☐ Very ☐ Satisfactory ☐ No opinion ☐ Unsatisfactory ☐ Very
satisfactory (no answer 4) Unsatisfactory
19. To what extent do you think MSDS sheets are satisfactory in providing you information to protect yourself? Please check one:
- (4) (8) (2) (2)
- ☐ Very ☐ Satisfactory ☐ No opinion ☐ Unsatisfactory ☐ Very
satisfactory (no answer 4) unsatisfactory
- 20-25. I would ask to see an MSDS:
Please circle to what extent you agree.
- | | Strongly agree | Agree | No opinion | Disagree | Strongly disagree |
|---|----------------|-------|------------|----------|-------------------|
| 20. During job planning | 5 (7)
NA-4 | 4 (6) | 3 (2) | 2 | 1(1) |
| 21. During job safety briefing | 5 (3)
NA-4 | 4 (8) | 3 (4) | 2 | 1(1) |
| 22. After job has started | 5 (1)
NA-5 | 4 (2) | 3 (2) | 2 (5) | 1(5) |
| 23. When first introduced to chemical | 5 (10)
NA-5 | 4 (1) | 3 (1) | 2 (5) | 1(7) |
| 24. After working with the chemical for some time | 5 (1)
NA-5 | 4 (1) | 3 (1) | 2 (5) | 1(7) |
| 25. Other, please specify _____ | | | | | |
26. How often do you use an MSDS when working with a chemical in your job? Please check one:
- ☐ Almost ☐ Often (4) ☐ Rarely (7) ☐ Almost (4)
always never
- ☐ Approximately equal in occurrence and nonoccurrence
(no answer 4)

H4. Pilot Results Worker Comments: MSDS Usage Inventory (Continued)

Source: Phillips, 1996.

27-32. The MSDS is difficult to understand because:
Please circle to what extent you agree.

		Strongly Agree	Agree	No opinion	Disagree	Strongly disagree
27.	Its words are difficult to understand	5 no answer	4 (2) 4	3 (4)	2 (9)	1 (1)
28.	It is hard to read	5 (2) NA-4	4 (4)	3 (1)	2 (9)	1
29.	It is too long to read	5 (2) NA-4	4 (2)	3 (3)	2 (7)	1
30.	It has a confusing format	5 (1) NA-4	4 (5)	3 (3)	2 (6)	1
31.	Its symbols are difficult	5 (1) NA-4	4 (2)	3 (8)	2 (3)	1
32.	Other, explain: _____					

33-34. Regarding the law requiring that MSDS:
Please circle to what extent you agree.

		Strongly Agree	Agree	No opinion	Disagree	Strongly disagree
33.	It should be repealed	5 NA-5	4	3 (3)	2 (9)	1 (3)
34.	The MSDS should remain even without a law	5 (8) no answer	4 (7) 4	3 (1)	2	1

H5. Pilot Results Worker Comments: MSDS Usage Inventory (Continued)

Source: As tabulated, 1996.

SUMMARY
MSDS COMPREHENSIBILITY TEST CRITIQUE

1. Easy to Understand. Yes 18 No 2
If not, why not?
Asks questions about MSDS before anyone sees it based on memory.
2. Does it ask appropriate questions? Yes 20 No
3. Is it too long? Yes 5 No 14 Med 1
4. How would you improve this questionnaire?
Don't ask question before MSDS applied.
Question NOT specific, answers did not always match MSDS.
#2 is very subjective, depending on site and emergency response requirements.
Questions on short term, long term, immediate seem very similar.
Shorten list of options, i.e., #2, #10, combine some of them.
5. Were instructions adequate? Yes 20 No
If not, explain:
6. Comments:
In spillage section, need to reference flammability issues MSDS is very confusing to pull out information employee needs (2B).
MSDS is too lengthy and complicated, vague on PPE (2A).
MSDS inadequate for areas of PPE.
Target organ section vague (1B).
Exposure to chemicals vague.
The questionnaire and test methodology appear to provide a good assessment of MSDS comprehension.
MSDS hard to understand, too wordy, vague, format, and length gave difficulty in finding answers.

H7. Pilot Results Worker Comments: MSDS Test Questionnaire

Source: As tabulated, 1996.

OSHA Type Format

<u>Group I</u>	<u>Pretest</u>	<u>Posttest</u>	<u>Gain off (+/-)</u>
1A	18	84	66
1B	36	79	43
1C	66	91	25
1D	30	77	47
1E	33	81	48

Gain average 46

ANSI/CMA

Group II

2A	47	67	20
2B	24	47	23
2C	17	88	71
2D	43	68	25
2E	62	53	-9

Average 26

ICSC

Group III

3A	54	77	23
3B	0	62	62
3C	14	72	58
3D	10	62	52
3E	7	48	41

Average 47

CONTROL

Control

4A	0	0	0
4B	40	49	9
4C	10	10	0
4D	23	23	0
4E	69	70	1

Average 2

H8. Pilot Results Worker Pretest and Posttest Scores

Source: As tabulated, 1996.

APPENDIX I
MSDS TEST ANSWER KEYS

**QUESTIONNAIRE CONTROL PRETEST AND POSTTEST
MEASUREMENT OF MSDS COMPREHENSIBILITY
Test Key OSHA Type Format**

Please answer all of the questions based on your knowledge about the chemical:

1. Who would you contact for more information about this chemical? Any response about the manufacturer, address, phone, sic code, etc. [10 pts.]
2. In the case of an accidental spill or leak, what should you do? Shut off all sources of ignition, evacuate area. Self Contained Breathing Apparatus (SCBA), rubber boots, heavy gloves, absorb on sand, vermiculite, place enclosed for disposal, ventilation, wash spill, consult expert.
3.
 - a. If there is a fire involving this chemical, what should you do? Alcohol resistant foam, powder, carbon dioxide, (No Water), water spray, SCBA, personal protective equipment (PPE), no contact skin and eyes. [10 pts.]
 - b. What precautions would avoid fires? No open flames, no smoking, no sparks [10 pts.]
4. What are the first aid procedures that you should follow if you or a co-worker has an exposure? Skin: flush with large volume of water. Remove clothing. Inhalation: immediately remove to fresh air, give oxygen if breathing labored. If breathing stopped, give CPR. Ingestion: If conscious, give ipecac to induce vomiting, call physician, rest. [10 pts.]
5. If you were working with this chemical, what type of personal protection would you expect to use? (Check all correct answers.)
 - ☒ Respirator
Type respirator NIOSH/MSHA approved breathing protection, or only exhaust hood.
 - ☒ Protective clothing
Type clothing Chemical resistant gloves, clothing, safety glasses
 - ☒ Eye protection
 - ☐ Other _____
 - ☐ Do not know

1.1. MSDS Test Answer Key OSHA Type Format

Source: Kearney/Centaur Division of A. T. Kearney, Inc. (1991a). The Comprehensibility of Material Safety Data Sheets, Final Report. Alexandria, VA and Phillips (1996).

6. What body system might be affected by a long-term exposure, over many years, to this chemical? (Check one or more.)
- ☒ Nervous (brain and nerves)
 - ☒ Digestive (stomach and bowels)
 - ☒ Respiratory (breathing - nose/lungs)
 - ☐ Bladder/Kidneys
 - ☐ Sexual function/Reproduction
(Impotence) (pregnancy problems/sterility)
 - ☐ Muscles
 - ☐ Skeleton (bones)
 - ☒ Heart/Blood/Circulation
 - ☒ Eyes/Ears
 - ☒ Liver
 - ☒ Skin
 - ☐ Other (please list) _____
 - ☐ Do not know
7. Does this chemical have the potential to cause cancer?
- ☐ Yes ☒ No ☒ Do not know [10 pts.]
8. What body systems may be immediately affected by an exposure? (Check all correct answers.)
- ☒ Nervous (brain and nerves)
 - ☒ Digestive (stomach and bowels)
 - ☒ Respiratory (breathing - nose/lungs)
 - ☐ Bladder/Kidneys

12. MSDS Test Answer Key OSHA Type Format (Continued)

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

- ☐ Sexual function/Reproduction
(Impotence) (pregnancy problems/sterility)
 - ☐ Muscles
 - ☐ Skeleton (bones)
 - ☐ Heart/Blood/Circulation
 - ☒ Eyes/Ears
 - ☒ Liver
 - ☒ Skin
 - ☐ Other (please list) _____
 - ☐ Do not know
9. What can be the immediate health effects caused by exposure to this chemical?
(Check one or more.)
- | | |
|--|--|
| ☒ Nausea and/or vomiting | ☒ Skin irritation |
| ☒ Dizziness | ☒ Loss of coordination |
| ☒ Loss of consciousness | ☐ Erratic behavior |
| ☐ Burns | ☐ Other (does not list) |
| ☒ Breathing difficulty | ☐ Do not know |
| ☒ Mental confusion/forgetfulness | |
10. How can this chemical enter your body? (Check one or more.)
- ☒ Breathing (lungs)
 - ☒ Eating/Drinking/Hand-to-mouth
 - ☒ Through the skin
 - ☒ Through the eyes
 - ☐ Do not know

13. MSDS Test Answer Key OSHA Type Format (Continued)

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

QUESTIONNAIRE PRETEST AND POSTTEST
MEASUREMENT OF MSDS COMPREHENSIBILITY
Test Key CMA/ANSI Z400.1 Format

Please answer all of the questions based on the information provided in the Material Safety Data Sheet (Refer to the MSDS):

1. Does this chemical have the potential to cause cancer?
☐ Yes ☒ No ☐ Does not say [10 pts.]

2. What body systems may be immediately affected by an exposure?
(Check all correct answers.) [10 pts.]
 - ☒ Nervous (brain and nerves)
 - ☒ Digestive (stomach and bowels)
 - ☒ Respiratory (breathing - nose/lungs)
 - ☒ Bladder/Kidneys
 - ☒ Sexual function/Reproduction
(Impotence) (pregnancy problems/sterility)
 - ☐ Muscles
 - ☐ Skeleton (bones)
 - ☐ Heart/Blood/Circulation
 - ☒ Eyes/Ears
 - ☐ Liver
 - ☒ Skin
 - ☐ Other (please list) _____
 - ☐ Does not say

14. MSDS Test Answer Key CMA/ANSI Z400.1 Format

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

3. a. If there is a fire involving this chemical, what does the Material Safety Data Sheet recommend? [10 pts.]
- Use water spray, dry chemical, carbon dioxide or chemical foam as in any fire, wear Self Contained Breathing Apparatus (SCBA) in press demand mode. MSHA/NIOSH approved or equivalent, and full protective gear, vapors controlled to a source of ignition and flash back.
- b. What precautions are suggested to avoid fires? [10 pts.]
- Avoid excess heat, avoid ignition sources, avoid static discharges.
4. What body system might be affected by a long-term exposure, over many years, to this chemical? (Check one or more.) [10 pts.]
- ☐ Nervous (brain and nerves)
 - ☒ Digestive (stomach and bowels)
 - ☒ Respiratory (breathing - nose/lungs)
 - ☐ Bladder/Kidneys
 - ☒ Sexual function/Reproduction (Impotence) (pregnancy problems/sterility)
 - ☐ Muscles
 - ☐ Skeleton (bones)
 - ☐ Heart/Blood/Circulation
 - ☐ Eyes/Ears
 - ☐ Liver
 - ☒ Skin
 - ☐ Other (please list) _____
 - ☐ Do not know

15. MSDS Test Answer Key CMA/ANSI Z400.1 Format (Continued)

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

5. How can this chemical enter your body? (Check one or more.) [10 pts.]
- ☒ Breathing (lungs)
 - ☒ Eating/Drinking/Hand-to-mouth
 - ☒ Through the skin
 - ☐ Through the eyes
 - ☐ Does not say
6. What are the first aid procedures that you should follow if you or a co-worker has an exposure? Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower lids. Get medical aid immediately. Do NOT swallow, victim to rub or keep eyes closed. Skin: get medical aid. Immediately flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Ingestion: Do NOT induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk and water. Never give anything by mouth to an unconscious person. Get medical aid immediately. Inhalation: Get medical aid immediately. Remove from exposure to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Notes to physician: Treat symptomatically and supportively. No specific antidote exists. [10 points]
7. If you were working with this chemical, what type of personal protection would you expect to use? (Check all correct answers.) [10 pts.]
- ☒ Respirator
Type respirator OSHA regulation 29 CFR 1910.134; NIOSH approved
 - ☒ Protective clothing
Type clothing Gloves, protective clothing-skin
 - ☒ Eye protection: Glasses, chemical goggles, (29 CFR 1910.133)
 - ☐ Does not say any of these
8. In the case of an accidental spill or leak, what does the Material Safety Data Sheet suggest that you do? Use proper personal protective equipment as indicated in Section 8. Spills/leaks: Absorb spill with inert material, (e.g., dry sand or earth), then place into a chemical waste container. Avoid runoff into stream sewers and ditches which lead to waterways. Clean up spills immediately, observing precautions in the protective equipment section. Scoop up with a nonsparking tool, then place into a suitable container for disposal. Remove all sources of ignition [10 pts.]

16. MSDS Test Answer Key CMA/ANSI Z400.1 Format (Continued)

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

9. Who would you contact for more information about this chemical, based on the Material Safety Data Sheet? Acros organic, Janessen Pharmaceutical 2440 Gell Belgium, U.S., 1-800-ACROS-01, Emergencies in US Chemtrec 1-800-424-9300. [10 pts.]

10. What can be the immediate health effects caused by exposure to this chemical?

(Check one or more.) [10 pts.]

- | | |
|--|---|
| ☒ Nausea and/or vomiting | ☒ Skin irritation |
| ☒ Dizziness | ☐ Loss of coordination |
| ☒ Loss of consciousness | ☐ Erratic behavior |
| ☐ Burns | ☐ Other (does not list) |
| ☒ Breathing difficulty | ☐ Does not say |
| ☐ Mental confusion/forgetfulness | |

17. MSDS Test Answer Key CMA/ANSI Z400.1 Format (Continued)

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

QUESTIONNAIRE PRETEST AND POSTTEST
MEASUREMENT OF MSDS COMPREHENSIBILITY
Test Key ICSC Format

Please answer all of the questions based on the information provided in the
Material Safety Data Sheet (Refer to the MSDS):

1. Does this chemical have the potential to cause cancer?
☐ Yes ☐ No ☒ Do not know [10 pts.]
2. What body systems may be immediately affected by an exposure?
(Check all correct answers.) [10 pts.]
 - ☒ Nervous (brain and nerves)
 - ☒ Digestive (stomach and bowels)
 - ☒ Respiratory (breathing - nose/lungs)
 - ☐ Bladder/Kidneys
 - ☐ Sexual function/Reproduction
(Impotence) (pregnancy problems/sterility)
 - ☐ Muscles
 - ☐ Skeleton (bones)
 - ☒ Heart/Blood/Circulation
 - ☒ Eyes/Ears
 - ☐ Liver
 - ☒ Skin
 - ☐ Other (please list) _____
 - ☐ Does not say

18. MSDS Test Answer Key ICSC Format

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

3. a. If there is a fire involving this chemical, what does the Material Safety Data Sheet recommend? [10 pts.]
Use alcohol resistant foam, powder, carbon dioxide. Do not use water.
- b. What precautions are suggested to avoid fires? [10 pts.]
No open flames. No sparks. No smoking.
4. What body system might be affected by a long-term exposure, over many years, to this chemical? (Check one or more.) [10 pts.]
- ☐ Nervous (brain and nerves)
 - ☐ Digestive (stomach and bowels)
 - ☐ Respiratory (breathing - nose/lungs)
 - ☐ Bladder/Kidneys
 - ☐ Sexual function/Reproduction
(Impotence) (pregnancy problems/sterility)
 - ☐ Muscles
 - ☐ Skeleton (bones)
 - ☐ Heart/Blood/Circulation
 - ☐ Eyes/Ears
 - ☐ Liver
 - ☒ Skin
 - ☐ Other (please list) _____
 - ☐ Do not know

19. MSDS Test Answer Key ICSC Format (Continued)

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

5. How can this chemical enter your body? (Check one or more.)
[10 pts.]
- ☒ Breathing (lungs)
 - ☒ Eating/Drinking/Hand-to-mouth
 - ☒ Through the skin
 - ☐ Through the eyes
 - ☐ Does not say
6. What are the first aid procedures that you should follow if you or a co-worker has an exposure? Fresh air, rest, medical attention after inhalation, remove contaminated clothes, rinse or shower after skin exposure. Remove contact lenses if easily possible. Rinse mouth, give plenty of water to drink. [10 pts.]
7. If you were working with this chemical, what type of personal protection would you expect to use? (Check all correct answers.)
[10 pts.]
- ☒ Respirator
Type respirator Type not identified
 - ☒ Protective clothing
Type clothing Gloves
 - ☒ Eye protection
 - ☐ Does not say any of these
8. In the case of an accidental spill or leak, what does the Material Safety Data Sheet suggest that you do? Consult air expert (waste combustion), collect leaking and spilled liquid in sealable container; absorb remaining liquid in sand or inert absorbent and remove to safe place. Don't wash away into sewer. [10 pts.]

19. MSDS Test Answer Key ICSC Format (Continued)

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

9. Who would you contact for more information about this chemical, based on the Material Safety Data Sheet? Does not say. [10 pts.]
10. What can be the immediate health effects caused by exposure to this chemical?
(Check one or more.) [10 pts.]
- | | |
|--|---|
| ☒ Nausea and/or vomiting | ☒ Skin irritation |
| ☒ Dizziness | ☐ Loss of coordination |
| ☐ Loss of consciousness | ☐ Erratic behavior |
| ☐ Burns | ☐ Other (does not list) |
| ☒ Breathing difficulty | ☐ Does not say |
| ☒ Mental confusion/forgetfulness | |

11. MSDS Test Answer Key ICSC Format (Continued)

Source: Kearney/Centaur, 1991b, and Phillips, 1996.

APPENDIX J
MSDS INVENTORY AND COMPREHENSIVE TEST
RESULTS (RAW DATA)

SUM OF INDIVIDUAL SCORES FOR PRETEST AND POSTTEST QUESTIONS

ALL QUESTIONS						WITHOUT QUESTION 10		
OBS	Form	ID	PRE	POST	DIFF	PRE	POST	DIFF
1	Control	68	37.51	32.49	-5.02	37.51	32.49	-5.02
2	Control	69	46.85	58.51	11.66	46.85	48.51	1.66
3	Control	70	34.81	40.44	5.63	34.81	40.44	5.63
4	Control	71	44.26	39.51	-4.75	44.26	39.51	-4.75
5	Control	72	45.68	32.27	-13.41	45.68	32.27	-13.41
6	Control	73	31.71	23.37	-8.34	31.71	23.37	-8.34
7	Control	74	35.11	35.11	0.00	35.11	35.11	0.00
8	Control	75	48.29	56.77	8.48	48.29	46.77	-1.52
9	Control	76	20.00	0.00	-20.00	20.00	0.00	-20.00
10	Control	77	0.00	0.00	0.00	0.00	0.00	0.00
11	Control	78	7.50	7.50	0.00	7.50	7.50	0.00
12	Control	79	19.69	28.98	9.29	19.69	28.98	9.29
13	Control	80	51.43	10.00	-41.43	51.43	10.00	-41.43
14	Control	81	40.49	13.70	-26.79	40.49	13.70	-26.79
15	Control	82	33.95	29.85	-4.10	33.95	29.85	-4.10
16	Control	83	51.11	50.04	-1.07	41.11	40.04	-1.07
17	Control	139	0.00	10.00	10.00	0.00	10.00	10.00
18	Control	140	0.00	10.00	10.00	0.00	10.00	10.00
19	Control	141	31.84	47.13	15.29	31.84	37.13	5.29
20	Control	142	50.00	55.73	5.73	50.00	55.73	5.73
21	Control	143	10.00	10.00	0.00	10.00	10.00	0.00
22	Control	144	10.00	10.00	0.00	10.00	10.00	0.00
23	Control	145	42.03	50.24	8.21	42.03	50.24	8.21
24	Control	146	25.70	22.97	-2.73	25.70	22.97	-2.73
25	Control	147	33.86	48.19	14.33	33.86	38.19	4.33
26	Control	148	50.41	39.36	-11.05	40.41	39.36	-1.05
27	Control	149	29.03	24.39	-4.64	19.03	24.39	5.36
28	Control	150	18.89	10.00	-8.89	18.89	10.00	-8.89
29	Control	151	43.80	58.58	14.78	43.80	48.58	4.78
30	Control	152	39.50	0.00	-39.50	39.50	0.00	-39.50
31	Control	153	57.83	56.49	-1.34	57.83	56.49	-1.34
32	Control	154	64.53	74.90	10.37	54.53	64.90	10.37
33	Control	155	32.52	36.89	4.37	32.52	36.89	4.37
34	Control	156	17.48	43.08	25.60	17.48	43.08	25.60
35	Control	157	49.86	45.19	-4.67	39.86	35.19	-4.67
36	Control	158	57.09	50.97	-6.12	47.09	40.97	-6.12
37	Control	159	49.50	51.70	2.20	49.50	51.70	2.20
38	Control	160	44.27	46.32	2.05	44.27	46.32	2.05
39	Control	161	38.30	37.48	-0.82	38.30	37.48	-0.82
40	Control	162	21.29	32.49	11.20	21.29	32.49	11.20

Summary statistics for the control form data.

Summary Statistics	All Questions			Without Question 10		
	Pre Test	Post Test	Difference	Pre Test	Post Test	Difference
Average	34.15	33.27	-0.89	32.65	31.02	-1.64
Std. Dev.	16.89	19.44	13.56	15.76	17.27	12.60
Minimum	0.00	0.00	-41.43	0.00	0.00	-41.43
Maximum	64.53	74.90	25.60	57.83	64.90	25.60

J.1 MSDS Comprehensive Test Results (Raw Data)

SUM OF INDIVIDUAL SCORES FOR PRETEST AND POSTTEST QUESTIONS

OBS	Form	ID	ALL QUESTIONS			WITHOUT QUESTION 10		
			PRE	POST	DIFF	PRE	POST	DIFF
41	ICSC	1	15.33	49.68	34.35	15.33	49.68	34.35
42	ICSC	2	50.47	84.96	34.49	50.47	84.96	34.49
43	ICSC	3	1.67	65.58	63.91	1.67	65.58	63.91
44	ICSC	4	66.62	90.00	23.38	56.62	90.00	33.38
45	ICSC	5	16.32	75.58	59.26	16.32	75.58	59.26
46	ICSC	6	17.33	81.30	63.97	17.33	81.30	63.97
47	ICSC	7	88.30	88.30	0.00	88.30	88.30	0.00
48	ICSC	8	53.31	83.26	29.95	53.31	83.26	29.95
49	ICSC	9	44.62	57.47	12.85	44.62	57.47	12.85
50	ICSC	10	30.99	68.29	37.30	30.99	68.29	37.30
51	ICSC	11	41.64	62.50	20.86	41.64	62.50	20.86
52	ICSC	12	0.00	72.00	72.00	0.00	72.00	72.00
53	ICSC	13	18.64	73.46	54.82	18.64	65.46	46.82
54	ICSC	14	6.99	56.63	49.64	6.99	56.63	49.64
55	ICSC	16	3.66	36.66	33.00	3.66	36.66	33.00
56	ICSC	17	25.31	30.37	5.06	25.31	30.37	5.06
57	ICSC	18	32.31	74.14	41.83	32.31	74.14	41.83
58	ICSC	19	37.64	61.00	23.36	27.64	61.00	33.36
59	ICSC	20	20.00	77.04	57.04	20.00	77.04	57.04
60	ICSC	21	16.98	37.67	20.69	16.98	37.67	20.69
61	ICSC	22	16.66	49.57	32.91	16.66	49.57	32.91
62	ICSC	23	5.00	72.88	67.88	5.00	72.88	67.88
63	ICSC	24	0.00	79.30	79.30	0.00	69.30	69.30
64	ICSC	25	0.00	60.00	60.00	0.00	60.00	60.00
65	ICSC	26	0.00	67.66	67.66	0.00	67.66	67.66
66	ICSC	27	6.66	39.13	32.47	6.66	39.13	32.47
67	ICSC	84	57.13	90.00	32.87	57.13	90.00	32.87
68	ICSC	85	51.00	66.63	15.63	51.00	66.63	15.63
69	ICSC	86	56.64	74.96	18.32	56.64	74.96	18.32
70	ICSC	87	49.96	79.97	30.01	49.96	79.97	30.01
71	ICSC	88	46.31	51.82	5.51	46.31	51.82	5.51
72	ICSC	89	45.64	74.64	29.00	45.64	74.64	29.00
73	ICSC	90	10.00	76.64	66.64	10.00	76.64	66.64
74	ICSC	91	39.96	100.00	60.04	39.96	90.00	50.04
75	ICSC	92	65.80	86.30	20.50	55.80	86.30	30.50
76	ICSC	93	0.00	84.96	84.96	0.00	84.96	84.96
77	ICSC	94	58.32	72.46	14.14	58.32	72.46	14.14
78	ICSC	95	44.98	71.31	26.33	44.98	71.31	26.33
79	ICSC	96	59.97	84.98	25.01	49.97	84.98	35.01
80	ICSC	97	0.00	72.30	72.30	0.00	72.30	72.30

Summary statistics for the ICSC form data.

Summary Statistics	All Questions			Without Question 10		
	Pre Test	Post Test	Difference	Pre Test	Post Test	Difference
Average	30.05	69.54	39.48	29.05	68.84	39.78
Std. Dev.	23.95	16.12	22.62	22.95	15.61	21.40
Minimum	0.00	30.37	0.00	0.00	30.37	0.00
Maximum	88.30	100.00	84.96	88.30	90.00	84.96

J2. MSDS Comprehensive Test Results (Raw Data)

SUM OF INDIVIDUAL SCORES FOR PRETEST AND POSTTEST QUESTIONS

OBS	Form	ID	ALL QUESTIONS			WITHOUT QUESTION 10		
			PRE	POST	DIFF	PRE	POST	DIFF
81	ANSI/CMA	28	36.04	53.94	17.90	36.04	43.94	7.90
82	ANSI/CMA	29	0.00	66.46	66.46	0.00	56.46	56.46
83	ANSI/CMA	30	38.24	88.55	50.31	38.24	78.55	40.31
84	ANSI/CMA	31	24.61	48.40	23.79	24.61	38.40	13.79
85	ANSI/CMA	32	31.02	76.28	45.26	31.02	66.28	35.26
86	ANSI/CMA	33	37.86	84.10	46.24	37.86	74.10	36.24
87	ANSI/CMA	34	30.88	32.43	1.55	30.88	32.43	1.55
88	ANSI/CMA	35	38.44	65.00	26.56	38.44	55.00	6.56
89	ANSI/CMA	36	56.36	89.30	32.94	46.36	79.30	32.94
90	ANSI/CMA	37	46.08	71.00	24.92	36.08	61.00	24.92
91	ANSI/CMA	38	52.20	79.30	27.10	42.20	69.30	27.10
92	ANSI/CMA	39	40.44	91.80	51.36	40.44	81.80	41.36
93	ANSI/CMA	40	45.60	71.00	25.40	45.60	61.00	15.40
94	ANSI/CMA	41	49.77	73.10	23.33	49.77	63.10	13.33
95	ANSI/CMA	42	50.01	80.40	30.39	50.01	70.40	20.39
96	ANSI/CMA	43	30.33	66.62	36.29	30.33	56.62	26.29
97	ANSI/CMA	44	0.00	75.76	75.76	0.00	65.76	65.76
98	ANSI/CMA	98	0.00	81.00	81.00	0.00	71.00	71.00
99	ANSI/CMA	99	49.64	71.80	22.16	49.64	61.80	12.16
100	ANSI/CMA	100	35.64	73.30	37.66	35.64	63.30	27.66
101	ANSI/CMA	101	24.32	74.48	50.16	24.32	64.48	40.16
102	ANSI/CMA	102	40.00	58.66	18.66	40.00	58.66	18.66
103	ANSI/CMA	103	54.16	70.46	16.30	54.16	70.46	16.30
104	ANSI/CMA	104	61.30	74.96	13.66	51.30	74.96	23.66
105	ANSI/CMA	105	41.64	37.45	-4.19	41.64	37.45	-4.19
106	ANSI/CMA	106	51.80	98.30	46.50	46.80	88.30	41.50
107	ANSI/CMA	107	45.64	72.78	27.14	45.64	62.78	17.14
108	ANSI/CMA	108	39.14	65.64	26.50	39.14	65.64	26.50
109	ANSI/CMA	109	43.96	63.94	19.98	43.96	53.94	9.98
110	ANSI/CMA	110	3.32	64.30	60.98	3.32	64.30	60.98
111	ANSI/CMA	111	45.80	80.32	34.52	45.80	70.32	24.52
112	ANSI/CMA	112	72.48	82.28	9.80	62.48	72.28	9.80
113	ANSI/CMA	113	38.96	52.62	13.66	38.96	52.62	13.66
114	ANSI/CMA	114	10.00	67.78	57.78	10.00	57.78	47.78
115	ANSI/CMA	115	54.80	83.83	29.03	44.80	73.83	29.03
116	ANSI/CMA	116	43.64	64.16	20.52	43.64	64.16	20.52
117	ANSI/CMA	117	44.30	81.00	36.70	44.30	71.00	26.70
118	ANSI/CMA	118	12.00	94.30	82.30	2.00	84.30	82.30
119	ANSI/CMA	119	58.14	78.13	19.99	58.14	78.13	19.99
120	ANSI/CMA	120	55.81	88.00	32.19	45.81	78.00	32.19

Summary statistics for the ANSI/CMA form data.

Summary Statistics	All Questions			Without Question 10		
	Pre Test	Post Test	Difference	Pre Test	Post Test	Difference
Average	38.36	72.32	33.96	36.23	64.82	28.59
Std. Dev.	17.57	14.14	20.25	16.39	12.46	18.84
Minimum	0.00	32.43	-4.19	0.00	32.43	-4.19
Maximum	72.48	98.30	82.30	62.48	88.30	82.30

J3. MSDS Comprehensive Test Results (Raw Data)

SUM OF INDIVIDUAL SCORES FOR PRETEST AND POSTTEST QUESTIONS

			ALL QUESTIONS			WITHOUT QUESTION 10		
OBS	Form	ID	PRE	POST	DIFF	PRE	POST	DIFF
121	OSHA Type	45	67.50	90.00	22.50	67.50	80.00	12.50
122	OSHA Type	46	0.00	88.00	88.00	0.00	78.00	78.00
123	OSHA Type	47	43.00	76.00	33.00	33.00	66.00	33.00
124	OSHA Type	48	53.00	90.00	37.00	43.00	80.00	37.00
125	OSHA Type	49	0.00	82.00	82.00	0.00	72.00	72.00
126	OSHA Type	50	6.25	88.00	81.75	6.25	78.00	71.75
127	OSHA Type	51	0.00	88.00	88.00	0.00	78.00	78.00
128	OSHA Type	52	5.00	66.75	61.75	5.00	66.75	61.75
129	OSHA Type	53	0.00	55.66	55.66	0.00	55.66	55.66
130	OSHA Type	54	51.25	71.00	19.75	51.25	61.00	9.75
131	OSHA Type	55	36.50	80.00	43.50	36.50	70.00	33.50
132	OSHA Type	56	33.50	53.75	20.25	23.50	43.75	20.25
133	OSHA Type	57	39.00	73.00	34.00	29.00	63.00	34.00
134	OSHA Type	58	38.25	90.50	52.25	38.25	80.50	42.25
135	OSHA Type	59	35.00	64.00	29.00	35.00	54.00	19.00
136	OSHA Type	60	29.41	93.75	64.34	29.41	83.75	54.34
137	OSHA Type	61	35.25	70.50	35.25	35.25	70.50	35.25
138	OSHA Type	62	37.75	66.00	28.25	37.75	66.00	28.25
139	OSHA Type	63	28.33	66.75	38.42	28.33	66.75	38.42
140	OSHA Type	64	30.00	35.00	5.00	30.00	35.00	5.00
141	OSHA Type	65	35.00	43.00	8.00	35.00	43.00	8.00
142	OSHA Type	66	36.25	71.25	35.00	36.25	61.25	25.00
143	OSHA Type	121	43.00	46.00	3.00	43.00	46.00	3.00
144	OSHA Type	122	38.16	93.50	55.34	38.16	83.50	45.34
145	OSHA Type	123	48.00	67.50	19.50	48.00	57.50	9.50
146	OSHA Type	124	51.50	73.16	21.66	41.50	63.16	21.66
147	OSHA Type	125	56.25	80.50	24.25	46.25	70.50	24.25
148	OSHA Type	126	45.25	82.00	36.75	45.25	82.00	36.75
149	OSHA Type	127	36.75	47.66	10.91	36.75	47.66	10.91
150	OSHA Type	128	35.66	64.50	28.84	35.66	64.50	28.84
151	OSHA Type	129	41.00	62.25	21.25	41.00	52.25	11.25
152	OSHA Type	130	30.00	78.50	48.50	30.00	68.50	38.50
153	OSHA Type	131	36.66	68.66	32.00	36.66	58.66	22.00
154	OSHA Type	132	42.66	81.50	38.84	42.66	71.50	28.84
155	OSHA Type	133	46.66	79.66	33.00	46.66	69.66	23.00
156	OSHA Type	134	31.41	76.00	44.59	31.41	66.00	34.59
157	OSHA Type	135	54.25	95.50	41.25	44.25	85.50	41.25
158	OSHA Type	136	47.50	84.25	36.75	47.50	74.25	26.75
159	OSHA Type	137	0.00	98.00	98.00	0.00	88.00	88.00
160	OSHA Type	138	0.00	96.00	96.00	0.00	86.00	86.00

Summary statistics for the OSHA Type form data.

Summary Statistics	All Questions			Without Question 10		
	Pre Test	Post Test	Difference	Pre Test	Post Test	Difference
Average	33.12	74.45	41.33	31.37	67.20	35.83
Std. Dev.	18.02	15.52	24.77	16.99	13.09	22.94
Minimum	0.00	35.00	3.00	0.00	35.00	3.00
Maximum	67.50	98.00	98.00	67.50	88.00	88.00

J4. MSDS Comprehensive Test Results (Raw Data)

1. 1,2,3,4,1,1,4,1,1,2,1,4,2,2,2,2,4,2,3,3,2,3,3,2,4,4,4,4,4,4,2,4,4,4,4,4,2,5,1
2. 1,2,2,3,1,1,4,1,1,2,3,4,1,1,1,2,2,1,5,5,5,2,5,1,5,5,5,5,2,2,5,5,5,2,2,4,4,1,5,1
3. 1,2,4,4,3,1,4,1,1,2,3,3,4,1,2,1,4,1,4,4,4,4,4,4,1,5,5,1,5,1,4,4,4,2,1,5,1,1,1,2,5,1
4. 1,2,3,3,1,1,4,1,1,2,3,4,1,1,1,1,2,3,5,5,5,4,3,4,1,5,5,4,5,3,1,5,1,1,4,5,2,2,4,4,1,5,1
5. 1,2,4,3,2,1,4,1,2,4,3,2,2,4,3,2,4,1,2,2,2,3,2,4,3,3,3,3,4,3,2,2,2,2,3,4,2,4,4,4,1,5,1
6. 1,2,2,3,1,1,4,1,1,1,1,2,2,1,2,2,4,2,3,4,4,3,2,2,2,4,4,2,4,1,4,4,4,4,4,5,1,1,4,4,1,5,2
7. 1,2,4,3,3,1,4,1,1,3,4,4,2,2,3,2,2,2,4,4,5,3,2,3,1,4,4,2,5,2,3,3,3,3,4,4,2,2,3,5,2,5,1
8. 1,2,3,4,2,1,2,1,1,3,3,4,2,2,3,2,3,3,1,1,2,2,2,2,1,2,2,2,5,2,2,3,4,3,3,4,3,2,4,4,1,5,1
9. 1,2,3,3,3,1,4,1,1,2,3,4,2,2,2,2,3,2,3,2,4,3,3,3,2,3,4,3,3,2,4,2,2,4,4,2,2,4,4,1,5,1
10. 1,2,4,3,3,2,0,0,0,2,3,4,2,2,2,2,1,3,2,4,3,3,3,4,4,3,3,4,3,2,4,4,2,4,4,2,2,4,4,2,4,2
11. 1,2,4,3,1,1,4,1,1,2,2,4,2,1,1,1,4,2,4,4,4,4,2,2,2,4,4,2,4,2,2,4,4,2,4,5,1,1,4,4,4,4,3
12. 1,2,3,4,3,1,2,1,1,3,1,3,3,4,2,2,4,2,1,1,1,4,3,3,3,3,4,3,4,3,4,2,3,4,4,4,2,3,3,2,4,2
13. 1,1,3,3,2,1,4,1,1,1,2,2,2,2,2,2,5,2,4,4,4,4,4,4,2,4,4,4,4,2,4,4,4,4,4,4,2,4,5
14. 1,2,4,3,1,2,0,0,0,2,3,2,3,2,2,2,4,2,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,2,4,2
16. 1,2,3,3,1,2,0,0,0,2,3,2,3,2,2,1,5,2,5,5,5,3,1,1,3,5,4,1,5,1,4,2,4,4,4,4,3,4,4,4,1,4,1
17. 1,2,4,3,3,2,0,0,0,1,2,4,3,2,3,2,5,3,3,3,3,3,3,3,2,3,3,3,3,3,3,4,4,3,3,4,2,4,3,4,4,4,5
18. 1,1,3,5,1,2,0,0,0,1,2,1,3,2,2,2,5,1,3,3,3,3,3,3,4,3,3,3,4,3,2,4,4,2,3,5,2,3,4,4,3,4,2
19. 1,2,4,3,3,2,0,0,0,1,3,2,3,3,3,2,5,1,3,3,3,3,3,3,5,3,3,3,3,3,3,3,3,5,1,3,3,5,2,5,5
20. 1,2,4,3,1,1,4,1,1,2,1,2,2,2,2,2,1,1,4,4,4,3,3,3,4,4,4,4,3,3,2,4,3,3,4,4,2,2,4,4,1,5,1
21. 1,2,4,3,3,1,1,2,1,2,1,2,2,3,2,2,5,1,4,4,5,4,4,5,1,4,4,2,5,1,3,3,3,3,4,4,2,2,3,2,2,5,1
22. 1,2,4,3,1,1,2,1,1,2,2,4,2,2,2,2,4,2,4,4,3,1,1,1,1,4,4,2,4,2,3,4,4,3,4,4,3,4,4,4,1,5,2
23. 1,2,3,3,2,2,0,0,0,2,3,2,2,1,1,1,3,1,4,3,4,2,2,2,2,3,3,2,4,2,2,4,4,2,4,4,2,4,4,4,2,4,2
24. 1,2,2,3,1,1,2,1,1,3,1,2,2,2,2,2,4,2,3,2,2,2,2,4,2,2,2,4,4,2,3,4,4,3,2,4,5,4,4,4,1,5,1
25. 1,1,3,3,2,2,0,0,0,2,2,2,2,1,2,1,4,1,5,5,4,5,4,4,4,4,4,4,4,4,2,4,2,2,4,4,2,2,4,4,2,4,4
26. 1,1,3,3,1,2,0,0,0,2,1,4,4,3,2,2,5,2,1,1,1,1,1,1,5,4,4,4,5,4,3,3,3,3,3,3,3,3,3,1,5,1
27. 1,2,4,5,3,1,2,1,1,2,2,2,2,2,2,2,1,2,2,2,2,2,2,5,5,5,2,4,4,2,3,4,4,4,4,4,4,4,4,1,5,1
28. 2,1,5,3,3,1,1,1,1,1,3,2,2,1,1,1,1,1,5,5,5,2,2,1,5,5,5,1,1,1,5,5,1,1,4,5,1,3,5,5,5,5,1
29. 2,1,3,3,2,1,2,1,1,2,1,2,2,2,2,2,4,2,3,3,4,4,3,3,2,4,4,4,4,3,2,4,4,2,4,4,2,3,5,5,2,4,2
30. 2,2,4,4,4,1,2,1,1,1,1,2,2,2,1,2,4,2,2,2,4,2,3,3,2,4,4,2,4,2,2,4,4,2,4,5,2,2,4,4,2,4,2
31. 2,2,3,3,1,1,4,1,1,4,1,3,2,2,3,2,2,2,2,2,4,3,3,3,2,2,4,2,4,2,2,4,4,2,4,4,2,4,4,4,2,4,2
32. 2,2,4,3,3,1,2,1,1,2,3,2,2,4,2,2,4,4,1,2,4,4,2,2,2,4,4,4,4,1,4,2,2,2,2,4,2,4,4,4,2,4,1
33. 2,2,3,3,1,1,2,1,1,3,2,4,2,2,1,1,2,2,5,5,5,5,5,1,1,5,5,5,5,1,2,5,2,2,4,5,1,1,5,5,1,5,1
34. 2,2,4,3,3,2,0,0,0,2,3,2,2,2,2,2,2,2,4,4,4,2,2,2,4,4,4,4,4,4,2,4,4,2,4,4,2,4,4,4,4,4,3
35. 2,2,4,4,2,1,1,1,1,2,3,2,2,2,2,2,4,2,3,4,2,4,2,2,2,4,4,2,4,1,2,4,4,2,4,4,2,3,4,4,1,5,1
36. 2,2,4,4,1,1,2,1,2,3,3,4,1,2,1,4,1,1,2,2,2,2,2,2,5,5,5,2,5,2,4,2,4,4,4,5,2,2,5,5,1,5,1
37. 2,2,3,3,2,1,2,1,1,3,2,2,2,1,2,1,5,3,4,4,5,3,3,5,3,4,4,4,4,5,4,2,3,4,3,5,1,1,5,5,1,5,1
38. 2,2,3,4,1,1,4,1,1,4,3,4,1,1,1,1,1,2,5,5,5,1,1,1,1,5,5,2,5,1,1,5,5,1,5,5,1,1,4,4,1,5,1
39. 2,2,2,4,1,1,4,1,1,3,3,4,2,2,2,2,2,1,4,4,4,4,2,2,2,5,5,4,5,2,4,2,2,5,4,4,2,2,2,4,1,5,2
40. 2,2,3,4,2,1,4,1,1,3,1,4,2,2,1,1,3,2,4,4,4,4,2,2,2,5,5,2,5,2,4,2,2,2,2,4,2,2,2,2,2,4,2
41. 2,1,3,3,3,1,4,1,1,3,3,3,2,2,2,2,4,2,4,4,4,4,4,4,4,4,4,4,4,2,2,4,4,2,2,4,4,4,4,2,4,2
42. 2,2,3,5,1,1,4,1,1,2,2,4,1,1,2,4,2,1,5,5,5,1,5,1,5,5,5,5,5,1,2,4,4,4,2,4,4,4,1,5,1
43. 2,2,2,4,1,1,2,1,1,2,3,4,2,2,2,2,4,2,3,4,4,4,3,3,3,3,4,4,5,3,3,3,4,3,4,4,3,3,4,3,2,4,2
44. 2,2,4,3,1,1,2,1,1,2,3,2,2,2,2,2,4,2,3,3,3,3,3,3,3,4,4,3,4,3,2,4,4,2,3,4,4,3,3,1,5,1
45. 3,2,4,4,3,2,0,0,0,2,1,1,3,3,3,3,5,3,1,1,1,1,1,5,2,2,2,2,3,3,3,3,5,2,2,3,5,4,5,1
46. 3,2,3,4,1,1,3,0,1,2,1,2,2,2,3,2,5,3,2,2,2,3,2,3,2,4,4,4,5,4,4,2,3,4,2,5,4,2,5,5,1,5,1

J5. MSDS Inventory Results (Raw Data)

47. 3,2,3,3,1,1,4,1,1,2,3,2,1,2,2,2,2,5,5,5,3,2,2,2,4,4,2,2,2,4,4,2,4,4,4,2,5,1
 48. 3,2,4,4,3,1,2,1,1,2,3,4,2,2,2,2,4,3,4,4,4,2,2,2,1,4,4,3,4,2,4,3,4,3,4,2,2,4,4,4,5
 49. 3,2,3,3,2,1,2,1,1,2,3,2,2,1,2,2,4,2,4,4,4,3,3,3,4,4,3,4,3,2,4,4,2,4,4,2,4,4,2,4,2
 50. 3,2,3,3,3,1,4,1,1,3,3,3,3,2,2,2,4,1,3,3,4,3,3,3,2,4,4,2,4,4,3,4,4,5,2,4,4,5,5,1
 51. 3,1,3,4,3,2,0,0,0,2,3,1,3,3,3,3,5,2,3,3,3,3,3,3,3,3,4,4,5,5,4,2,3,4,2,5,2,5,5,5,4,5,1
 52. 3,2,3,4,3,2,0,0,0,2,1,3,1,1,1,4,1,5,5,5,1,1,1,1,5,5,1,5,1,1,5,3,1,5,5,1,1,5,5,1,5,1
 53. 3,2,4,3,3,2,0,0,0,2,2,4,3,1,3,2,4,3,3,3,3,3,3,2,4,4,4,4,4,2,2,4,3,5,3,3,4,4,2,4,2
 54. 3,2,5,4,3,2,0,0,0,2,2,2,1,1,1,1,4,1,5,5,5,5,1,1,1,5,5,2,5,2,3,4,4,2,4,5,2,2,5,5,1,5,1
 55. 3,2,2,4,1,1,2,1,1,2,2,3,1,2,2,2,4,2,3,4,4,3,3,4,2,3,4,4,4,2,4,2,4,4,3,4,3,2,3,3,1,5,1
 56. 3,2,2,3,1,2,0,0,0,2,2,2,3,1,2,1,5,4,3,4,5,3,2,1,2,4,4,2,5,1,2,4,4,2,5,5,2,4,4,4,2,5,1
 57. 3,2,3,4,3,1,1,1,1,2,1,2,2,1,2,2,4,1,5,5,5,1,1,1,1,5,5,2,5,5,2,4,4,2,4,5,2,5,5,5,2,5,1
 58. 3,2,2,4,1,1,4,1,1,3,3,4,2,2,2,2,4,3,3,4,4,2,4,3,3,3,4,2,3,3,4,4,3,4,2,2,4,4,2,4,2
 59. 3,2,3,3,3,1,2,1,1,2,1,2,2,2,3,2,4,3,1,2,5,2,2,2,1,4,2,1,5,2,4,2,1,4,2,4,3,4,5,5,2,5,1
 60. 3,2,3,3,3,2,0,0,0,1,1,1,3,3,3,3,5,2,3,3,3,3,3,3,5,3,3,3,3,5,2,3,4,2,4,4,4,4,4,3,4,3
 61. 3,2,2,3,1,1,1,1,1,3,3,2,1,1,1,2,4,1,3,4,4,2,2,2,2,4,3,4,4,2,2,4,4,2,4,5,2,2,2,2,5,1
 62. 3,2,3,3,1,1,1,1,1,2,3,2,1,2,1,1,1,4,4,4,4,3,4,1,5,5,4,4,3,2,4,3,3,4,5,2,3,4,4,1,5,1
 63. 3,2,2,3,1,2,0,0,0,1,1,4,1,1,1,1,1,4,4,4,4,3,5,1,4,4,4,5,4,2,4,4,3,4,5,3,3,4,4,2,5,1
 64. 3,2,5,3,3,2,4,2,2,2,2,1,3,2,2,1,5,1,4,4,5,3,4,3,2,4,4,3,3,2,2,4,3,5,4,4,2,5,1,4,5,2,4
 65. 3,2,4,3,3,2,0,2,2,2,2,1,3,2,2,1,5,2,4,4,5,3,3,4,3,4,4,3,5,3,4,4,5,4,5,5,2,3,3,4,4,4,3
 66. 3,2,3,3,1,1,1,1,1,4,3,4,1,1,1,1,2,1,5,5,5,5,1,5,1,5,5,1,5,1,1,5,5,1,5,5,2,5,2,5,1,5,1
 68. 0,2,2,3,1,1,1,0,1,2,3,2,2,2,2,2,4,2,2,4,4,4,2,4,2,2,4,2,2,2,2,4,4,4,2,2,4,4,1,5,1
 69. 0,2,4,3,2,1,2,1,1,2,2,2,2,2,3,2,4,2,1,1,4,1,1,4,2,4,4,3,5,4,4,2,3,4,3,5,2,3,4,4,1,5,1
 70. 0,1,3,3,1,1,4,1,1,2,2,2,2,2,1,1,4,1,1,2,4,2,2,2,2,2,2,2,2,2,2,4,3,3,5,4,2,3,4,4,2,4,2
 71. 0,1,3,3,2,1,1,1,1,3,2,2,2,2,2,2,4,2,4,4,4,2,2,2,1,4,4,2,4,2,2,4,2,2,2,4,2,2,4,1,4,1
 72. 0,2,3,3,3,1,2,1,1,2,3,3,2,2,2,2,4,2,2,2,2,2,2,2,2,2,4,2,4,2,3,2,3,3,2,4,2,3,3,4,2,4,4
 73. 0,2,2,3,2,1,4,1,1,2,4,4,2,2,3,2,4,1,4,4,4,3,2,2,2,4,3,2,4,2,2,3,2,4,4,4,2,2,4,4,1,5,1
 74. 0,2,5,2,4,1,3,1,1,2,3,2,2,2,2,2,2,2,4,4,5,4,4,5,4,5,4,3,2,4,4,4,4,4,2,5,5,5,2,4,2
 75. 0,2,2,4,1,1,2,2,1,3,2,2,2,2,2,2,4,2,2,4,4,3,1,1,2,2,4,4,4,2,2,4,4,3,4,4,3,2,2,4,2,5,2
 76. 0,2,2,3,2,1,1,0,1,2,3,2,2,1,2,1,4,1,5,5,5,3,3,3,2,4,4,2,4,2,2,4,4,2,4,5,1,1,3,5,2,4,2
 77. 0,2,2,3,1,2,0,0,0,2,1,2,2,2,2,2,1,1,4,4,5,4,1,1,1,5,5,1,1,1,2,4,4,3,3,5,3,3,5,5,1,5,1
 78. 0,2,3,3,3,2,0,0,0,2,4,2,3,3,3,2,5,2,3,3,3,3,3,3,4,3,3,3,3,2,4,4,2,4,4,4,4,4,2,5,2
 79. 0,2,2,3,2,1,1,2,1,1,4,2,3,3,3,3,4,3,4,4,4,2,4,2,3,3,3,4,3,3,3,3,3,4,3,4,4,4,2,4,3
 80. 0,2,2,3,1,1,4,1,1,3,2,3,1,2,2,2,2,2,3,3,4,3,3,3,2,4,4,4,5,3,4,2,4,4,3,4,3,4,4,4,2,5,1
 81. 0,2,2,3,1,1,4,1,1,2,2,2,2,2,2,2,3,1,2,2,4,2,2,2,2,4,4,2,2,2,4,4,4,2,2,3,4,4,2,4,2
 82. 0,2,3,3,1,2,0,0,0,2,3,2,2,4,2,2,2,2,4,4,4,4,5,2,4,3,3,5,4,5,3,4,4,5,5,4,4,4,5,2,5,2
 83. 0,2,3,3,3,1,4,1,1,2,1,1,3,3,4,2,4,4,2,2,2,2,3,3,4,4,4,4,2,4,4,4,2,2,4,4,4,4,4,1,5,2
 84. 1,2,4,5,3,1,1,2,2,2,4,2,3,3,3,2,5,1,2,2,2,3,3,2,4,3,3,3,4,3,2,4,2,2,4,4,2,2,4,4,2,4,2
 85. 1,2,4,4,2,1,4,2,2,4,2,4,1,1,1,1,1,5,5,5,5,5,5,5,5,5,5,5,4,4,5,4,5,5,4,5,5,5,1,5,1
 86. 1,2,3,3,3,1,2,1,1,4,2,4,2,2,2,2,2,5,4,5,2,2,4,2,5,5,5,5,2,2,4,2,4,4,5,2,2,4,4,2,4,2
 87. 1,2,3,3,1,1,4,1,1,2,4,2,3,3,3,3,4,2,3,3,4,3,3,3,3,4,4,2,4,2,3,4,3,3,4,4,3,3,4,4,4,2
 88. 1,2,4,3,2,2,0,0,0,2,3,2,2,2,2,2,4,2,3,3,3,3,3,3,3,3,3,3,4,2,2,4,2,4,4,4,4,4,2,4,2
 89. 1,2,3,4,2,1,1,0,1,2,1,2,4,3,3,4,4,3,3,3,3,3,3,3,4,2,3,4,3,5,4,4,5,3,4,2,5,3,3,1,5,1
 90. 1,2,2,3,1,1,1,2,1,2,1,2,2,2,2,2,5,2,3,3,3,3,3,3,3,4,4,4,4,4,4,2,4,4,4,4,3,4,4,1,4,2
 91. 1,2,3,3,2,1,4,1,1,2,1,2,2,1,2,2,4,2,3,4,4,2,1,4,2,4,4,2,4,2,2,4,4,2,4,4,2,3,4,4,1,5,1

J6. MSDS Inventory Results (Raw Data)

92. 1,2,3,3,1,1,4,1,1,3,3,3,2,2,2,1,4,2,4,4,5,3,3,3,1,4,4,2,5,1,2,3,4,2,4,5,2,3,4,4,2,4,2
 93. 1,2,3,3,3,1,4,1,1,2,2,4,2,2,2,2,1,4,4,5,4,4,5,2,4,5,4,5,2,4,4,3,3,4,5,3,3,4,4,1,5,1
 94. 1,2,4,4,4,1,4,1,1,2,2,4,1,1,2,2,3,1,4,3,5,2,2,2,1,4,4,3,5,1,2,2,4,2,4,5,2,2,5,5,2,5,2
 95. 1,1,3,3,2,1,4,1,1,2,3,3,4,2,2,2,4,2,4,4,3,3,2,3,4,4,2,4,2,2,4,3,2,4,4,2,2,4,4,2,2,2
 96. 2,2,3,1,1,4,1,1,3,4,4,2,2,2,1,2,1,5,3,5,5,3,5,1,4,4,4,5,3,2,2,2,2,4,4,2,2,4,4,1,5,2
 97. 1,2,4,3,3,1,3,1,1,2,4,2,3,1,2,2,4,2,2,3,2,2,2,2,3,4,4,2,4,2,2,3,4,3,3,3,3,3,4,4,2,4,2
 98. 2,2,2,3,1,2,0,0,0,2,2,2,3,2,3,2,4,2,3,3,4,3,2,4,2,3,3,3,5,1,4,2,3,3,3,4,2,3,4,4,5,5,1
 99. 2,2,3,4,1,1,2,1,1,2,2,2,2,2,3,2,4,1,3,3,2,2,2,2,2,4,3,4,2,2,2,4,2,3,5,2,2,4,4,2,4,2
 100. 2,2,5,3,2,2,0,0,0,1,2,2,1,2,2,1,5,1,5,5,5,2,2,2,2,5,5,2,5,2,4,4,2,4,5,5,2,2,4,4,4,4,2
 101. 2,1,3,4,1,2,0,0,0,2,2,4,2,2,2,4,3,2,4,2,2,2,4,2,4,4,2,4,2,2,3,2,4,2,4,4,4,4,2,4,2
 102. 2,1,3,3,2,1,1,1,1,2,2,2,2,2,2,4,2,4,4,4,5,4,5,1,4,4,4,4,5,4,4,2,4,4,2,3,3,4,2,4,2
 103. 2,1,3,3,1,2,0,0,0,2,3,4,2,1,1,1,4,1,4,4,5,5,4,4,1,4,5,4,5,4,5,4,4,2,4,5,1,3,5,5,1,5,1
 104. 2,1,3,3,1,2,0,0,0,2,3,4,2,1,1,1,4,1,4,4,4,5,4,4,1,4,4,2,5,2,1,4,3,2,5,5,2,3,5,5,1,5,1
 105. 2,2,4,2,3,1,1,2,2,2,4,1,1,1,1,1,5,5,5,5,1,1,1,5,5,2,5,1,1,5,5,2,4,4,2,4,5,5,1,5,1
 106. 2,2,3,3,2,1,2,1,1,2,2,4,3,2,2,4,4,3,1,2,4,3,3,4,1,2,3,4,4,3,4,1,2,1,1,4,2,3,5,5,1,5,1
 107. 2,2,3,3,1,2,0,0,0,2,1,2,1,1,2,2,4,1,4,4,4,4,4,3,4,4,4,4,2,5,2,4,4,4,5,4,5,5,5,5,2
 108. 2,1,3,3,1,2,0,0,0,1,1,2,2,2,2,5,2,4,4,4,4,3,4,2,4,4,2,4,2,4,3,2,4,5,2,2,4,4,1,5,2
 109. 2,2,3,3,1,2,2,1,1,2,1,4,2,2,2,4,2,2,2,4,2,2,2,2,2,2,4,2,2,4,4,3,4,4,3,2,4,4,1,5,1
 110. 2,2,3,3,1,1,1,1,1,2,2,2,2,2,2,4,3,2,4,4,3,3,3,1,4,4,3,4,2,3,2,2,4,2,4,2,3,4,4,2,4,2
 111. 2,2,4,4,3,1,1,0,2,2,4,4,2,2,2,3,2,4,3,4,2,2,2,3,3,4,4,2,3,2,3,2,4,4,2,3,4,4,2,4,2
 112. 2,2,1,3,1,1,4,1,1,2,1,4,2,2,2,2,1,4,3,5,4,3,5,2,5,4,3,4,4,2,4,4,3,4,5,3,3,4,4,2,4,2
 113. 2,2,5,4,1,2,0,0,0,2,2,3,2,2,2,3,2,4,4,2,2,2,2,4,4,4,4,2,2,4,4,2,2,4,2,4,4,4,2,4,2
 114. 2,2,4,3,3,2,0,0,0,2,1,1,3,3,3,3,5,2,3,3,3,3,3,3,3,3,3,3,3,3,3,3,4,4,4,4,3,4,2
 115. 2,2,4,3,1,1,1,2,1,2,2,2,2,2,2,4,4,3,3,3,4,3,4,4,4,4,2,3,4,4,3,4,4,3,4,4,4,2,4,1
 116. 2,2,4,3,4,1,4,1,1,4,2,2,2,4,2,4,2,2,4,4,2,2,4,4,5,4,5,4,4,2,2,2,3,4,4,4,4,2,5,1
 117. 2,2,3,4,2,1,2,1,1,2,2,2,2,3,2,4,2,4,4,4,3,2,2,3,4,4,4,4,2,3,4,4,4,3,4,4,4,3,3,4,2
 118. 2,1,3,4,2,1,4,2,2,2,3,4,2,3,2,2,4,2,2,4,3,4,4,2,4,4,3,4,4,4,3,2,4,3,4,2,4,4,4,1,5,2
 119. 2,2,2,3,1,1,4,1,1,2,3,4,1,1,1,1,1,2,3,3,4,1,1,1,1,5,5,3,5,1,2,4,4,2,4,5,1,1,4,5,2,5,2
 120. 2,2,2,4,1,1,4,1,1,1,3,4,2,1,1,1,4,2,2,2,5,5,5,5,2,2,4,2,4,4,2,2,2,2,4,4,3,2,4,2,5
 121. 3,1,3,3,1,2,0,0,0,1,1,2,2,2,2,5,2,4,4,4,4,4,4,4,4,4,4,4,2,4,4,2,4,4,2,4,4,4,4,2,4,4
 122. 3,2,2,3,1,1,2,1,1,2,1,4,2,1,2,2,4,2,4,4,4,3,3,1,2,4,2,4,2,4,4,2,5,1,2,4,4,1,5,1
 123. 3,2,4,3,2,1,1,1,1,2,2,2,4,1,1,1,3,1,5,5,4,5,4,4,5,5,5,5,5,4,4,3,5,5,2,4,5,5,2,5,2
 124. 3,2,3,3,2,1,4,1,1,2,1,3,2,1,2,2,3,1,5,4,4,2,2,2,2,4,4,2,4,2,4,3,3,3,4,4,2,3,3,2,5,3
 125. 3,2,3,3,3,1,4,1,1,4,2,4,2,1,2,1,3,1,4,3,4,4,3,3,1,5,5,3,5,3,3,4,3,4,4,4,4,4,4,1,5,1
 126. 3,1,3,3,1,1,2,1,1,2,1,4,1,1,1,1,4,1,5,1,1,1,1,1,1,4,4,2,5,1,1,5,5,1,4,3,4,5,3,3,1,5,1
 127. 3,2,4,4,1,1,1,1,1,2,2,2,2,2,2,1,2,4,4,4,3,3,3,3,4,4,4,4,4,2,4,3,3,4,3,2,4,4,1,4,1
 128. 3,2,3,3,1,2,0,0,0,2,1,2,2,2,2,4,2,4,4,4,3,2,1,3,4,4,2,1,1,4,2,2,5,5,4,5,4,4,4,2,5,2
 129. 3,1,3,3,1,1,4,1,1,2,2,2,1,1,1,1,2,1,5,5,5,5,5,5,1,5,5,5,5,5,4,4,4,2,4,5,2,2,5,5,2,4,2
 130. 3,2,3,3,2,1,2,1,1,2,1,2,2,2,2,2,4,2,2,2,2,4,3,4,2,2,4,2,4,2,4,2,4,2,4,2,4,4,4,2,4,2
 131. 3,2,4,3,3,2,0,0,0,2,1,2,2,2,2,5,2,4,4,5,2,2,2,2,4,4,2,5,2,3,3,3,3,4,4,2,3,4,4,5,5,2
 132. 3,2,3,3,2,1,4,1,1,2,3,4,2,2,2,3,2,2,2,2,3,3,3,2,2,2,4,2,2,4,4,2,4,4,2,4,4,4,2,5,1
 133. 3,2,4,3,2,1,2,1,1,2,2,2,2,1,2,1,2,1,5,5,5,5,5,5,4,4,4,5,4,2,2,2,2,4,4,4,4,4,4,4
 134. 3,2,4,3,3,2,0,0,0,2,2,2,3,1,2,2,4,1,4,4,4,5,4,5,4,4,4,5,3,4,4,2,2,4,5,2,4,4,4,2,4,2

J7. MSDS Inventory Results (Raw Data)

135. 3,2,4,4,3,1,4,1,1,2,3,3,1,1,1,1,2,1,4,5,5,4,2,2,2,5,5,2,5,2,2,4,2,2,4,5,2,2,5,5,1,5,1
 136. 3,2,4,3,1,1,3,1,1,2,3,2,2,2,2,4,2,2,2,2,3,3,4,2,3,3,2,4,4,2,4,4,3,4,5,2,3,4,4,2,4,2
 137. 3,2,2,3,1,2,0,0,0,2,1,1,2,3,2,4,5,2,2,2,2,2,4,4,4,4,4,4,4,1,4,5,2,4,2,4,5,5,1,5,2
 138. 3,2,3,4,3,1,1,1,1,2,3,2,4,2,2,2,4,1,2,2,4,2,2,4,2,2,4,2,2,4,2,2,4,4,3,4,4,2,4,1
 139. 0,2,4,3,1,1,1,1,1,2,2,2,2,2,2,1,2,3,4,4,3,3,3,3,4,4,4,4,4,2,4,3,3,4,3,2,4,4,1,4,1
 140. 0,2,4,3,1,1,2,1,1,2,2,2,2,1,2,2,4,1,3,1,1,1,1,1,1,4,4,1,5,1,5,1,5,5,1,5,1,1,5,5,1,5,1
 141. 0,2,5,3,1,1,2,1,1,2,3,4,2,2,2,2,4,2,2,4,4,4,2,2,1,4,4,2,4,2,2,3,2,4,4,4,2,4,4,2,4,2
 142. 0,2,3,3,3,1,4,1,1,2,2,4,1,1,1,1,1,1,5,5,5,1,1,1,1,5,5,1,5,1,1,5,5,1,4,5,1,5,5,1,5,1
 143. 0,2,3,3,3,1,4,1,1,3,3,3,2,2,2,2,2,1,4,5,5,1,1,1,1,5,5,1,5,1,1,4,2,4,4,5,5,1,1,5,5,1,5,1
 144. 0,2,2,3,1,1,2,1,1,2,1,2,3,2,2,2,5,1,3,4,2,2,2,4,2,3,3,3,3,4,2,4,2,3,4,3,2,4,4,2,5,1
 145. 0,2,3,5,1,1,2,1,1,2,3,4,2,2,2,2,4,2,3,3,3,3,3,3,3,3,5,5,2,4,4,2,4,5,2,3,3,3,2,5,2
 146. 0,2,3,4,1,1,2,1,1,2,3,4,2,2,2,3,2,3,3,4,3,3,4,4,4,4,3,2,4,4,2,4,5,3,4,4,4,4,5,2
 147. 0,2,2,4,1,1,1,2,1,2,4,1,2,2,2,2,5,1,1,1,1,5,5,5,5,5,5,5,5,5,2,5,5,1,5,2,2,5,5,1,5,1
 148. 0,2,3,4,3,1,3,1,1,2,3,2,1,1,1,1,3,1,4,4,4,4,4,4,2,4,4,4,4,5,4,3,4,4,3,4,2,3,3,4,1,5,1
 149. 0,2,3,3,1,1,4,1,1,2,3,4,1,2,2,2,4,1,4,4,4,2,2,2,2,4,4,2,4,2,4,4,2,4,4,2,4,3,3,4,4,1,5,2
 150. 0,2,3,3,1,2,0,0,0,2,3,2,1,2,2,2,4,2,2,4,4,3,2,2,2,2,4,2,2,2,2,4,4,2,4,4,2,3,4,4,2,4,2
 151. 0,2,3,5,2,1,3,1,1,2,2,2,2,2,2,2,2,1,4,4,4,4,4,4,2,4,4,4,4,4,2,4,4,2,4,4,2,3,4,4,2,4,2
 152. 0,2,3,4,1,2,0,0,0,2,1,2,2,2,2,2,4,2,4,4,4,4,4,4,2,4,4,4,4,4,2,4,4,4,4,4,2,4,4,2,5,1
 153. 0,2,3,3,1,2,0,0,0,1,3,2,2,3,2,2,4,2,4,4,5,3,3,5,1,4,4,3,5,2,4,2,4,4,4,4,2,3,4,4,4,5,2
 154. 0,2,2,3,1,2,0,0,0,2,2,4,2,2,2,2,4,2,3,4,4,2,2,2,2,4,4,2,4,2,3,4,4,4,4,5,1,1,5,5,2,4,2
 155. 0,2,3,3,2,1,4,2,2,2,2,2,3,2,2,3,5,2,1,1,2,3,3,4,3,3,3,4,4,4,2,3,4,4,4,2,3,4,4,2,5,2
 156. 0,2,3,3,1,1,1,0,1,2,3,2,2,2,2,1,4,2,4,4,4,2,2,2,2,4,4,4,4,2,2,4,4,4,4,4,2,4,3,4,1,5,1
 157. 0,2,2,3,1,1,2,1,1,2,2,2,3,2,2,2,3,3,2,2,4,4,3,2,4,4,2,4,4,3,2,4,4,2,4,4,2,3,4,4,2,5,1
 158. 0,2,3,4,1,1,4,1,1,2,2,2,1,2,2,2,4,1,4,4,5,4,2,2,2,5,5,2,5,1,2,4,4,3,4,5,2,2,4,5,1,5,1
 159. 0,2,2,3,1,1,4,1,1,2,1,2,3,1,2,2,2,1,4,4,4,4,4,1,1,4,4,4,4,3,3,3,4,3,4,2,3,3,4,2,5,2
 160. 0,2,3,4,1,2,0,0,0,2,1,3,2,2,2,2,5,1,2,3,4,4,2,5,1,4,5,3,5,1,2,4,4,2,4,5,1,4,3,3,1,5,1
 161. 0,2,3,3,2,2,0,0,0,2,2,2,2,2,2,2,4,2,4,4,4,2,2,2,2,4,4,2,4,2,4,4,4,2,4,4,2,4,4,2,5,2
 162. 0,2,3,4,3,1,1,1,1,2,2,2,2,2,2,2,3,2,2,2,2,2,2,2,2,4,4,2,4,2,4,4,4,4,4,4,4,4,4,2,4,2

J8. MSDS Inventory Results (Raw Data)

VITA

Charles Clifford Phillips, Jr., son of Buena Phillips and Charles C. Phillips, was born in Lakeland, Florida on January 30, 1947. Raised in Newport News, Virginia, he graduated from East Tennessee State University in 1969 with a Bachelor of Science in Environmental Health and as a Distinguished Military Graduate, ROTC. He was commissioned in the Medical Service Corps, U.S. Army working in Preventive Medicine Service in Europe and United States from 1969-1989. During military service 1974-1975, he returned to East Tennessee State University and earned a Master of Science in Environmental Health. Upon retirement from the U.S. Army in 1989, he accepted a position with Martin Marietta Energy Systems, Oak Ridge National Laboratory, as an Industrial Hygiene Manager. In 1991, he began work toward completion of the requirement for his Ph.D. He has been active in related professional organizations and is a member of Phi Kappa Phi and Pi Lambda Theta honor societies.