PB83-197012

Final Report on Contract Number 210-79-0018

Contract Title: Long-Term Effects of Learned Safety Skills

Report Title: Demonstration of the Effectiveness of an Industrial Lift Truck Operator Safety Training Program Utilizing a Behavior Sampling Procedure

Authors: H. Harvey Cohen, Principal Investigator
Safety Sciences, Division of WSA, Inc.

Roger C. Jensen, Project Officer
Division of Safety Research
National Institute for Occupational Safety and Health

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO.

2. NA

3. Recipient's Accession No. PB83 197012

4. Title and Subtitle
Long Term Effects of Learned Safety Skills

5. Report Date

6. NA

7. Author(s)
H. Cohen, R. Jensen

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Safety Sciences
Division of WSA, Inc.

10. Project/Task/Work Unit No. NA

11. Contract(C) or Grant(G) No.
(C) 2]0-79-00]8
(G)

12. Sponsoring Organization Name and Address
NIOSH
4676 Columbia Parkway
Cincinnati, Ohio 45226

13. Type of Report & Period Covered

14. NA

15. Supplementary Notes

16. Abstract (Limit: 200 words)

Over the years, safety training has been heavily depended upon to provide a means of reducing occupational accidents, yet, the literature lacks reports of definitive research demonstrating the value of safety training and the length of its effectiveness. The literature which abounds consists largely of course descriptions, lesson plans, and programs in use by companies or proposed by individuals. Few of these reports are based on an assessment of need through task analysis and only one study has been found which measured the effects of safety training on on-the-job performance.

The two studies described in this paper were initiated by the National Institute for Occupational Safety and Health in order to clarify knowledge concerning the value of occupational safety training and the influence of post-training management actions on the safety performance of workers engaged in a semi-skilled job. Industrial lift truck operators were selected for study because industrial lift trucks are widely used throughout industry, lift truck operations demonstrate ahigh risk and propensity for accidents, and the risk of injury associated with typical lift truck operations depends to a large extent on the performance of the operators, although the vehicle, workplace layout, and the task are also factors.

17. Document Analysis a. Descriptors

safety, behavioral-effects, occupational-safety-and-health-programs, accident-statistics

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement:
AVAILABLE TO THE PUBLIC

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 46

22. Price

(See ANSI–Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4–77) (Formerly NTIS–35) Department of Commerce

INTRODUCTION

Over the years, safety training has been heavily depended upon to provide a means of reducing occupational accidents, yet, the literature lacks reports of definitive research demonstrating the value of safety training and the length of its effectiveness (Surry, 1969) The literature which abounds consists largely of course descriptions, lesson plans, and programs in use by companies or proposed by individuals. Few of these reports are based on an assessment of need through task analysis and only one study has been found which measured the effects of safety training on on-the-job performance (Komaki, Heinzmann, and Lawson, 1980).

The actions of management following the training are critically intertwined with the training in affecting on-the-job performance. Post-training actions can range from no follow-up to extensive programs involving elements of goal setting, performance monitoring, feedback, and rewards. Goal-setting is an approach for improving performance on tasks in which performance is largely a function of the workers' conscious aspirations (Das, 1982). The goals may be established by management or by a worker participation approach. To be effective the goals should be accepted and achievable by the individual or group for which the goals are established (Locke, 1968). Feedback is a means of improving or sustaining performance by providing information about actual performance to the worker (Meister, 1976; Das, 1982; McCormick and Sanders, 1982). Rewards are used to reinforce desired behaviors and to provide motivation for sustaining achievable performance levels (Cohen, Smith, and Anger,

1979). All of these approaches require an objective and meaningful measure of performance.

The importance of having an objective and meaningful measure of performance is also essential when conducting research into the effectivness of training and management programs for improving worker safety. Traditional measures of safety performance, such as lost-time accidents, are "rare events" in the statistical sense, and consequently, not sensitive enough to evaluate the effectiveness of specific intervention programs in a single establishment.

A more sensitive measure (Rockwell, 1959; Tarrants, 1980) uses operationally defined performance criteria for measuring the effectiveness of program intervention through a work sampling procedure commonly used by industrial engineers for making determinations such as the portion of time a particular machine is in use. Similarly, when work sampling is used for monitoring human behavior it is also appropriate to dichotomize the behavior into distinguishable categories such as proper or improper, wearing or not wearing a hardhat, standing or walking, etc.

Rockwell indicated that such surrogate safety performance measures should be: observable in order that they can be measured; quantifiable in order to permit the use of statistical inference; reliable to the extent that they provide minimum variability when repeatedly measuring the same condition; and valid such that they are related to factors precipitating frequent and severe accidents which repeatedly occur.

A few studies have used behavioral sampling methods to evaluate the effects of behavioral safety programs in various work settings (Smith et al., 1978; Komaki et al., 1978; Zohar, et al., 1980; Komaki et al., 1980). The study by Komaki et al. (1978) used a behavioral sampling approach for demonstrating the beneficial effects of a combined safety training plus performance feedback intervention program. This was followed by a second workplace study (Komaki et al., 1980) designed to determine the effects of the safety training separately from the effects of performance feedback. The study found that safety training alone resulted in improved performance, while training combined with post-training feedback yielded even better performance.

The extent to which employee training and/or management programs produce improved behavior following cessation of the formal intervention program is a related question which needs investigation. Komaki et al. (1978) found that when the research team stopped monitoring the workers' performance and providing feedback, the performance deteriorated back to the level before the intervention began. Zohar (1980) suggests that a "holistic modification approach" in which workers' behavior and managerial standards are concurrently modified, may be the ingredient necessary for sustaining desired changes in group norms. In such an interactive system, new workers introduced to the plant would be encouraged by both management and their peers through ongoing performance feedback to model the modified group norms, thereby sustaining the desired group performance.

The two studies described in this paper were initiated by the National Institute for Occupational Safety and Health in order to clarify knowledge concerning the value of occupational safety training and the influence of post-training management actions on the safety performance of workers engaged in a semi-skilled job. Industrial lift truck operators were selected for study because industrial lift trucks are widely used throughout industry, lift truck operations demonstrate a high risk and propensity for accidents, and the risk of injury associated with typical lift truck operations depends to a large extent on the performance of the operators, although the vehicle, workplace layout, and the task are also factors.

METHOD

The basic approach followed Goldstein's model (1974) which specifies three major phases for a quality training program: (1) needs assessment, (2) program development, and (3) program evaluation.

Needs Assessment

The needs assessment involved the determination of existing knowledge concerning lift truck safety and an analysis of injury data. The search for existing knowledge identified: (1) research and technical reports related to lift truck safety and behavioral observation methodology; (2) ANSI (American National Standards Institute) and OSHA standards for safe lift truck operation; (3) a number of operating equipment manuals from a large variety of lift truck manufacturers; and (4) all available media, both movie and slide presentations, and workbook training courses on industrial lift truck operation and safety--none of which were found to be suitable for the purposes of these studies.

The injury data analysis consisted of the following: (1) approximately one thousand lift truck accident reports from a national data base of over 10,000 general industry accident cases; and (2) several hundred lift truck accident reports from the two warehouse participants, over a period of three years preceding the studies.

Training Program Development

The program development involved a series of tasks. Pre-baseline observations of both warehouse sites were made in order to identify those recurrent behaviors most suitable for training purposes as well as to become familiar with the warehouse facilities for purposes of detailing the studv protocol. For example, information was obtained on the layout of the warehouses, the breakdown of personnel by departments and workshifts, the different types of operations involved, etc.

A detailed task/hazard analysis was developed in order to derive a rational basis for development of the training program. Based on all the above information, each operational task was broken down in detail and the following information provided: (1) the necessary knowledge and skill requirements; (2) the potential consequences of behavioral errors; and (3) criticality ratings based on actual frequency and severity data obtained from the injury data analysis. (see Exhibit A).

From the task/hazard analysis and pre-baseline observations of participant warehouse operations, operator behaviors were identified which met the following criteria: (1) capable of being operationally defined, i.e., measurable; (2) frequently observable; (3) capable of being reliably observed; (4) related to frequent accident occurrence, i.e., valid; and (5) most amenable to a training-type, corrective action approach, rather than those behaviors which are best modified through other means, such as equipment or job redesign.

The training mode involved a professionally voiced slide/sound presentation in order to enhance the efficiency, practicality, and future utility of the program. As a companion to the audiovisual material, a detailed instructor's manual was prepared. The manual presented: (1) specific training and behavioral objectives, (2) a word-for-word copy of the voiced script with pictures, and (3) detailed instructions for course implementation.

The training program consisted of five sessions: one introductory session, three instructional sessions, and one "hands-on" practice exercise. The individual sessions took about 20 to 45 minutes for presentation, and were delivered on five successive work days. Each of the three instructional sessions was developed around five critical behaviors meeting the above criteria, for a total of 15 operationally defined, safe work practices, around which the entire training and performance feedback program was based.

The three instructional sessions, utilizing the audiovisual material, were set up in the following manner. A first slide introduced the situation to be trained. A second slide or set of slides showed typical incorrect ways of handling the situation. A third slide or set of slides showed the correct procedure. This approach ensured that the proper safe work practice was the last bit of information presented to the trainees.

Active learning was promoted through two types of trainee participation. First, semi-structured discussion immediately followed each training item (behavior). Also, in the final (fifth) session, a practice exercise was developed which required performance of all behaviors and promoted a peer modeling approach to reinforcement of correct work practice. The peer modeling approach required all trainees to score, and thus observe the performance (correct or incorrect) of each trainee as he went through the entire practice course layout. Scores were specifically not intercompared so as to avoid promoting competition.

A post-training management program was also developed. It consisted of several elements. Daily feedback, or knowledge of results, in the form of verbal and posted summaries of group performance was provided. This was combined with group performance goal setting i.e., a goal of better than 80% overall correct performance was agreed upon by the group. The trainer, a first-line supervisor meeting specific criteria of leadership, experience and communication skills, provided performance feedback including individualized coaching as necessary, in a positive, constructive and confidential manner. Essentially the supervisor/trainer acted as a coach of correct work practices, much as a sports coach instructs members of his team to refinements in their game. Thus, progressive increments in desired behavior were shaped on an individual basis as required. Finally, all levels of management had input into the development and execution of both the training and management program and firmly supported it throughout. The program was designed to be a company program, i.e., it met company needs, was developed and executed with management assistance, and was provided to management in final form for continued use.

Thus, the training was reinforced by combining elements of: (1) trainee participation; (2) performance feedback; (3) group performance goal setting; (4) peer group modeling; and ultimately (5) management support and follow through.

Program Evaluation

The program evaluation was based on the results of on-the-job behaviors observed before and after the training. Of the fifteen criterion behaviors used in the training program, fourteen proved usable as measures of performance. One behavior requested by management was not included in the final analysis due to limited opportunity for observation. Three observers were trained in precise methods for observing the criterion behaviors. A separate training program was developed for observers and they practiced at a practice warehouse (also the site where training program slides were taken) until their interobserver reliabilities exceeded .8 on the Cohen's Kappa Statistic (Cohen, 1960). Cohen's Kappa controls for chance agreement and is, therefore, more conservative than percent agreement. Actually, interobserver reliability exceeded .9 during the data collection phases of the study, a level considered to be exceptional. Weekly checks on observer reliability were made throughout the assessment phases of both studies.

Each warehouse was divided into eight observation locations. Observers rotated through these locations according to a rotation schedule, which ensured a random starting point and equal coverage by all observers. An observer stayed in a single location for approximately one-half hour, and then rotated stations. Observer rest breaks were interspersed throughout the daily session. All shift hours were sampled.

The fifteen behaviors were arrayed as columns on a data recording sheet. After a lift-truck operator drove within an observation location, the observer filled out a row on the data recording sheet by marking a plus for each observed behavior which was correctly performed, a minus for each observed behavior which was incorrectly performed, and a zero for each behavior which was not observed.

Frequency counts and error rates were computed daily. Computer printouts were provided to the supervisor/trainer for daily performance feedback to those operators receiving feedback.

Experimental Settings

Two studies, each employing a different experimental design, were performed. The two studies utilized two separate warehouses. The warehouses were both large, regional, "big ticket" distribution operations for two major, national retailers. Both were located in Southern California, and, despite different managements, displayed remarkably similar operational and employee characteristics. For example, both facilities were new, each employed 48 lift truck operators (all 96 of whom were eventually trained), all operators were male, and turnover was negligible in both warehouses. Table I presents a summary of some employee characteristics at the two participant warehouses.

(Table 1 here)

STUDY 1

Experimental Design.

The first study, conducted at warehouse 1, utilized a between and within groups comparison design. Treatment groups were assigned in the following manner. Operators were stratified by vehicle type (e.g., forks, clamps, appliance handlers, cherry picker), department (which corresponded to different vehicle types), and relative exposure (i.e., observation frequency established during pre-baseline observations).

Within each of the above strata, all lift truck operators were randomly assigned to one of three groups (12 operators per group): (1) a training only group; (2) a training-plus-feedback group; and (3) a control group which received no training and no feedback until after the Post-training I observation period. Observations were compared both before and after training separately for each of the three groups.

Another 12 employees who were occasional lift truck operators were eventually trained along with the control group because management requested that they be trained. However, observational data from these occasional operators were not included in the Post-training II and Retention phases of the study.

The experiment was divided into four phases: (1) the Pre-training phase during which none of the operators had been trained; (2) the Post-training I phase during which the control group remained untrained, the treatment group had received training, and the treatment-plus-feedback group had received training and were also receiving performance feedback; (3) the Post-training II phase during which all three groups had received training but only the training-plus-feedback group received performance feedback; and (4) the Retention phase which started three months after the end of the Post-training II phase (and the end of the feedback program).

Observations were double-blind, i.e., at no time were either observers or operators informed that different treatments were being evaluated, nor did they know to which group operators had been assigned. The operators in the control group and the occasional operators were told that they would be trained at a later time due to schedule constraints. Operators were recognized by a reliable, two-step coding system utilizing composite pictures and code names, the key to which was available only at the remote data processing center. In a very short time, operators were easily "recognized" by observers without the need to resort to the composite pictures provided for verification, simply through code names, which were designated according to some distinguishing feature or characteristic of the operator.

Results

Figure 1 and Tables 2-5 summarize the results of Study 1. Figure 1 and Table 2 show that pre-training error rates were comparable and stable for all three experimental groups, averaging .34. Following the initial training all three groups showed a decrease in their mean error rates (see Table 3) with the training-plus-feedback group showing the largest decrease (23%) followed by the training only (18%) and control (6%) groups. The calculated F value was significant at the .01 level, $F(2,38)=7.58$. Post-hoc analysis, using the Duncan Multiple Range Procedure, indicated that the training and training-plus-feedback groups each differed from the control group ($p < .05$), during the Post-training I phase, but did not differ significantly from one another when individual values were examined throughout the duration of the Post-training I treatment phase. Toward the end of the Post-training I phase the error rates of the three groups tended to converge, suggesting that the effects of the intervention program had begun to wear off. Observers also noted that some behaviors were becoming compromised when trained operators had to interact with untrained, control group operators, particularly when the behaviors involved conflict avoidance situations such as signaling and yielding at blind intersections.

(Figure 1, Table 2, and Table 3 here)

Following the Post-training I phase the control group and occasional operators were trained so that during the Post-training II phase all operators had been trained. The results presented in Table 3 indicate that the performance of all three groups improved (greatest for the original control group--28% versus 7% and 4% added improvement for the training-plus-feedback and training only group, respectively). Subsequent discussions with operators indicated that a peer modeling influence was taking over, i.e., the control group operators were modeling the behavior of their previously trained counterparts. Similarly, meeting other operators in potential conflict avoidance situations, such as occurred at intersections, was now reinforcing to the originally trained operators because nearly all operators were utilizing the correct procedures, e.g., signaling and yielding. Further evidence of modeling can be deduced from the finding during Post-training I that "control group" operators actually showed a slight improvement of 6% over baseline <u>before</u> they were formally trained

Each phase of training program assessment represented a duration of about one calendar month. After completion of the Post-training II phase, about three months' was allowed to elapse before returning to warehouse 1 to see if retention of the safe work practices had occurred. The results are shown graphically on Figure 1. The mean group error rates reported in Table 2 showed an additional improvement, decreasing from a rate of 0.25 in the Post-training II phase to 0.19 in the Retention phase.

The total performance gain demonstrated in Study 1 was 44% improvement from pre-training (baseline) levels. A one-way analysis of variance for performance error rate as a function of successive phases of the training program in warehouse 1 indicated a strong treatment effect, $\underline{F}$ (2, 29) = 61.67, $\underline{p} < 0.0001$. Post-hoc comparisons using the Duncan test demonstrated that more errors were observed during the Pre-training phase than during each of the successive phases, i.e., Post-training I, Post-training II, and Retention. In other words, there were significantly fewer errors at each successive phase of training program assessment.

Table 4 shows the percentage change in mean error rate for each of the fourteen individual behaviors used for performance evaluation. Improvement occurred in twelve behaviors. Not unexpectedly, one behavior (keeps all body parts within the truck) showed no improvement from its initial low error rate of 0.01 in warehouse 1. The other behavior which did not improve was the behavior which calls for the trucks to be driven in reverse. The mean error rate actually increased slightly from 0.49 to 0.51. Inquiry into the latter behavior revealed that operators at this warehouse resisted this change in behavior because the lift trucks in warehouse 1 were propane powered (as opposed to clean burning, battery powered lift trucks in warehouse 2) and driving in reverse caused them to breathe in noxious fumes. Furthermore, continuous looking over one's shoulder is an unnatural and uncomfortable posture to assume for prolonged periods.

(Table 4 here)

Table 5 shows a breakdown of individual behaviors by number and percent of total observations. The distribution of observation rates indicates a range of about 1 to 16% for individual behaviors with a median of about 9%. Clearly, no single behavior could be considered dominant to the point of skewing the results. Furthermore, the very stable and significant results of this study are clearly due to a combination of high inter-observer reliability coupled with the rather large number of observations (N = 50,488).

(Table 5 here)

STUDY 2

Experimental Design.

A second study was conducted in order to verify and extend the findings of the first study. The goal was to partially replicate the findings and hopefully demonstrate an even stronger effect due to introduction of the training program. Consequently, a modified experimental design was employed in order to eliminate the partially mitigating influence of the experimental groups interacting in conflict avoidance situations such as those which occur at intersections.

In the second study performed at a second warehouse (previously described), a within groups only comparison was performed. That is, all 48 lift truck operators at warehouse 2 were trained at the same time, and they all received performance feedback. Comparisons were made only before and after training. In addition, the schedule of the second study was abbreviated because it was clear from the results of the first that less time and a fewer number of observations would be sufficient in order to achieve stable and significant results, especially with the even lower error term expected utilizing a within subjects design. Each phase of the study, therefore, corresponded to two calender weeks of observation time.

Results.

The results of the second study are presented in Figure 2 and Tables 6-9. Figure 2 and Table 6 show that pre-training error rates were stable, averaging .23. Post-training error rates were likewise very stable throughout the observation period (Sessions 7-12), resulting in an immediate 61% improvement in performance scores.

(Figure 2 here)

Once again, the study team returned to the second warehouse, after a period of three months following post-training observations in order to see if retention of the modified work practices had occurred as was observed in warehouse 1. Similar to the findings of the first study, not only was retention of the safe work practices evident, but an additional reduction of 22% in mean error rates was observed, thus closely corresponding to the 24% additional gain demonstrated in Study 1.

(Table 6 here)

The overall net improvement in mean error rates (Table 7) due to the training and feedback program was indeed stronger than that observed in Study 1 (70% vs. 44%) and was highly significant, F (2, 16) = 307.75, $p < .0001$. Post-hoc analyses using the Duncan test confirmed that mean errors at each phase of training program assessment were significantly different. In other words, pre-training errors were clearly greater than those at post-training, which in turn were significantly higher than those observed during the retention phase, all in the predicted direction. The very strong and stable effects were, once again, attributed to the large number of observations (N = 12,107) and high interobserver reliability coupled with the modified experimental design which served to minimize experimental error.

(Table 7 here)

Table 8 shows that large improvement occurred for all behaviors, even behaviors 11 and 14 which manifested differently in Study 1. Overall pre-training error rates were lower for the second warehouse as compared to the first (.23 vs. .34) as were overall mean error rates during the final (retention) assessment phase of both studies (.07 vs. .19). Indeed improvement was generally stronger for all behaviors observed in warehouse 2 despite the fact that operators there generally exhibited fewer errors prior to the introduction of training.

(Table 8 here)

Table 9 shows that, similar to Study 1, no single behavior dominated the observed effects, with percent of total observations for each behavior ranging from about 1 to 15% with, once again, a median of about 9%. In point of fact, the actual distribution of percent observations seen for warehouse 2 in Table 9 versus that obtained from warehouse 1 in Table 5 is remarkably similar, which supports the impression that the functions and activities at the two warehouse facilities were quite comparable.

(Table 9 here)

DISCUSSION AND CONCLUSION

These two studies made use of a behavioral (work) sampling procedure to obtain objective data about work practices which correlate with injury risk. Although the technique has been rarely used in the past, it proved to be an invaluable method for objectively measuring the effects of safety training. It also proved useful in serving as the basis for training program development and providing performance feedback.

Visibility is a real problem with present lift truck designs. This is underscored by the results of our injury data analysis, as well as that of Coleman et al., (1978), that the majority of lift truck accidents occur to pedestrians and not to the operator himself. While it is true that driving in the forward direction limits the operator's clear view of the path ahead, a rule which requires truck operators to twist their necks for long periods of time (and, perhaps breathe in noxious fumes from LP-gas powered trucks) in order to look over their shoulders in the rearward direction of travel, is clearly not an optimal situation from an ergonomics point of view. In addition to the unnatural and uncomfortable neck twisting posture required for frequent rearward maneuvering, visibility is still restricted, particularly on the operator's blind side. This and other problems such as non-standardized controls which violate population stereotypes, point to the pressing need for increased use of improved ergonomically-designed lift trucks, which, in turn, should further serve to enhance safe lift truck operation.

The results of the two studies show that a well designed and administered occupational safety training program, emphasizing safe work practices and derived from a true assessment of need, can be effective in improving on-the-job behavior. Even better performance can be achieved by following the training with a program based on goal setting and performance feedback supplemented with informal peer group modeling. This is similar to the conclusions reached by Locke (1980) in an assessment of past research. Additionally, the improved performance can also endure well beyond the cessation of daily performance monitoring and feedback. The explanation for the enduring effects of the program appears to be that habits were changed due to continued practice in the safe work procedures, coupled with a redefinition of group norms which is self-sustained through the interacting influences of peer modeling of desired behaviors and continued management support of the program.

These conclusions support that of Zohar (1980) which suggest that informal influences, such as peer modeling and management support, are the ultimate and most practical types of reinforcement necessary to <u>sustain</u> modified, safe work practices, following cessation of any variety or combination of more formalized, behavior management programs such as performance feedback, goal setting, supervisor praise, and rewards.

REFERENCES

Cohen, A. Smith, M. J., and Anger, W. K. Self-protective measures against workplace hazards. Journal of Safety Research, 1979, 11, 121-131.

Cohen, J. A coefficient of agreement for nominal scales. Educational and Psychological Measurement, 1960, 20(1), 37-46.

Coleman, P. J., Gottlieb, M. S., Kaplan, M. C., Knutson, S. J. and McPeek J. S. Human factors analysis of materials handling equipment. Springfield, VA: National Technical Information Service, Number 81-16-77-44, January 1978.

Das, B. Effects of production feedback and standards on worker productivity in a repetitive production task. IIE Transactions, 1982, 14, 27-37.

Goldstein, I. L. Training: program development and evaluation. Belmont, California: Brooks/Cole, 1974.

Komaki, J., Barwick, K. D., and Scott, L. R. A behavioral approach to occupational safety: pinpointing and reinforcing safe performance in a food manufacturing plant. Journal of Applied Psychology, 1978, 63, 434-445.

Komaki, J., Heinzmann, A. T., and Lawson, L. Effect of training and feeback: Component analysis of a behavioral safety program. Journal of Applied Psychology, 1980, 65, 261-270.

Locke, E. A. Toward a theory of task motivation. Organizational Behavior and Human Performance, 1968, 3, 157-189.

Locke, E. A. Latham versus Komaki: a tale of two paradigms. Journal of Applied Psychology, 1980, 65, 16-23.

McCormick, E. J. and Sanders, M. S. Human factors in engineering and design, 5th Edition. New York: McGraw-Hill, 1982, 580-586.

Meister, D. Behavioral foundations of systems development. New York: John Wiley, 1976.

Rockwell, T. H., Safety performance measurement. The Journal of Industrial Engineering, 1959, 10, 12-16.

Smith, M. S. Anger, W. K., and Uslan, S. S. Behavior modification applied to occupational safety. Journal of Safety Research, 1978, 10, 87-88.

Surry, J. Industrial accident research. Toronto, Ontario, Canada: Labour Safety Council, Ontario Department of Labour, 1969, (reprinted 1974).

Tarrants, W. E. The measurement of safety performance. New York: Garland, 1980.

Zohar, D. Promoting the use of personal protective equipment by behavior modification techniques. Journal of Safety Research, 1980, 12, 78-85.

Zohar, D., Cohen, A., and Azar, N. Promoting increased use of ear protectors in noise through information feedback. Human Factors, 1980, 22, 69-79.

ACKNOWLEDGMENTS

This study was performed by Safety Sciences under contract 210-79-0018 with NIOSH. The authors wish to acknowledge the valuable technical contributions made by Michael Romansky, Ralph Turner, Ralph Plummer, and Margaret Hubbard Jones, as well as the managerial support provided by James Oppold and D. M. J. Compton.

BIOGRAPHICAL INFORMATION

H. HARVEY COHEN and ROGER C. JENSEN (Demonstration of the Effectiveness of an Industrial Lift Truck Operator Safety Training Program Utilizing a Behavior Sampling Procedure)

H. HARVEY COHEN is Vice-President for Human Factors and Training in the Safety Sciences Division of Syncor International, San Diego, California. Dr. Cohen received his Ph.D. from North Carolina State University in 1972 with an emphasis on industrial psychology and human factors engineering. Before joining Safety Sciences in 1976 he spent 4 years with the National Institute for Occupational Safety and Health performing studies concerning factors in successful safety programs and developing a research-oriented accident investigation methodology. He is a member of the Human Factors Society.

ROGER C. JENSEN is Chief of the Accident and Injury Epidemiology Branch, Division of Safety Research, National Institute for Occupational Safety and Health (NIOSH). Since joining NIOSH in 1969 his work has involved industrial hygiene, ergonomics, and safety engineering. He holds a masters degree in industrial engineering from the University of Michigan and a Juris Doctor degree from Northern Kentucky State University. Mr. Jensen is a licensed attorney, registered professional engineer, and a member of the Human Factors Society.

TABLE 1

Summary of Certain Lift Truck Operator Characteristics at the Two Participant Warehouses

Whse	Age	Marital Status	Experience at Job (Years)	Education Level (Years)	Accident Frequency Per Operator 3 Year Per.	Accident Severity (Lost Workdays Per LWD Case)
1	x = 34.2	Married = 71%	x = 7.6	x = 11.7	x = 1.1	x = 16.7
	R = 23 - 50	Single = 21%	R = 1 -20	R = 6 - 14	R = 0 - 4	R = 1 - 89
		Divorced = 8%				
2	x = 33.9	Married = 66%	x = 6.9	x = 12.2	x = 1.0	x = 15.7
	R = 21 - 48	Single = 25%	R = 1 - 18	R = 8 - 14	R = 0 - 3	R = 1 - 76
		Divorced = 9%				

TABLE 2

Sumary of Mean Error Rates (Warehouse 1)

Group	Pre-training	Post-training I	Post-training II	Retention
CONTROL	.34	.32	.23	
TRAINING	.33	.27	.25	
TRAINING PLUS FEEDBACK	.35	.27	.25	
ALL OPERATORS	.34	.27	.25	.19

TABLE 3

Percent Decrease in Mean Error Rates (Warehouse 1)

Group	Pre-training vs. Post-training	Post-training I vs. Post-training II	Post-training II vs. Retention	Pre-training vs. Retention
CONTROL	6%	28%		
TRAINING	18%	4%		
TRAINING PLUS FEEDBACK	23%	7%		
ALL OPERATORS		11%	24%	44%

TABLE 4

Percent Change in Error Rates for Individual Behaviors (Warehouse 1)

BEHAVIOR	PRE-TRAINING MEAN ERROR RATE	RETENTION MEAN ERROR RATE	PERCENT CHANGE IN ERROR RATE
1. WARNS TRUCKS	.82	.50	39%
2. YIELDS TO TRUCKS	.68	.44	35%
3. WARNS COWORKERS	.89	.42	53%
4. YIELDS TO COWORKERS	.93	.37	60%
5. SOUNDS HORN AT BLIND INTERSECTION	.86	.53	38%
6. SLOWS DOWN AT BLIND INTERSECTION	.67	.47	30%
7. LOOKS/BLIND INTERSECTION	.67	.38	43%
8. LOOKS IN DIRECTION OF TRAVEL	.33	.19	42%
9. MAINTAINS MODERATE SPEED	.42	.20	52%
10. AVOIDS QUICK STARTS/ CHANGES OF DIRECTION	.25	.14	44%
11. KEEPS ALL BODY PARTS WITHIN TRUCK	.01	.01	0
12. MAINTAINS FORKS IN PROPER POSITION	.31	.13	58%
13. MAINTAINS BALANCED LOAD	.13	.04	69%
14. DRIVES IN REVERSE	.49	.51	-4%
ALL BEHAVIORS	.34	.19	44%

TABLE 5

Percent of Total Observations for Individual Behaviors (Warehouse 1)

BEHAVIOR	NUMBER OF OBSERVATIONS	PERCENT OF TOTAL OBSERVATIONS
1. WARNS TRUCKS	392	1%
2. YIELDS TO TRUCKS	617	1%
3. WARNS COWORKERS	816	2%
4. YIELDS TO COWORKERS	1393	3%
5. SOUNDS HORN AT BLIND INTERSECTION	769	2%
6. SLOWS DOWN AT BLIND INTERSECTION	766	2%
7. LOOKS/BLIND INTERSECTION	731	1%
8. LOOKS IN DIRECTION OF TRAVEL	7849	15%
9. MAINTAINS MODERATE SPEED	6383	13%
10. AVOIDS QUICK STARTS/ CHANGES OF DIRECTION	5141	10%
11. KEEPS ALL BODY PARTS WITHIN TRUCK	7915	16%
12. MAINTAINS FORKS IN PROPER POSITION	7685	15%
13. MAINTAINS BALANCED LOAD	4306	9%
14. DRIVES IN REVERSE	5725	11%
ALL BEHAVIORS	50,488	100%

TABLE 6

Summary of Mean Error Rates (Warehouse 2)

Pre-training	Post-training	Retention
.23	.09	.07

TABLE 7

Percent Decrease in Mean Error Rates (Warehouse 2)

Pre-training vs. Post-training	Post-training vs. Retention	Pre-training vs. Retention
61%	22%	70%

TABLE 8

Percent Change in Error Rates for Individual Behaviors (Warehouse 2)

BEHAVIOR	PRE-TRAINING MEAN ERROR RATE	RETENTION MEAN ERROR RATE	PERCENT CHANGE IN ERROR RATE
1. WARNS TRUCKS	.18	.04	77%
2. YIELDS TO TRUCKS	.28	.11	61%
3. WARNS COWORKERS	.64	.13	80%
4. YIELDS TO COWORKERS	.64	.24	63%
5. SOUNDS HORN AT BLIND INTERSECTION	.31	.06	81%
6. SLOWS DOWN AT BLIND INTERSECTION	.63	.25	60%
7. LOOKS/BLIND INTERSECTION	.42	.13	69%
8. LOOKS IN DIRECTION OF TRAVEL	.30	.11	63%
9. MAINTAINS MODERATE SPEED	.24	.09	63%
10. AVOIDS QUICK STARTS/ CHANGES OF DIRECTION	.14	.03	79%
11. KEEPS ALL BODY PARTS WITHIN TRUCK	.15	.02	87%
12. MAINTAINS FORKS IN PROPER POSITION	.16	.07	56%
13. MAINTAINS BALANCED LOAD	.12	.04	67%
14. DRIVES IN REVERSE	.17	.03	82%
ALL BEHAVIORS	.23	.07	70%

TABLE 9

Percent of Total Observations for Individual Behaviors (Warehouse 2)

BEHAVIOR	NUMBER OF OBSERVATIONS	PERCENT OF TOTAL OBSERVATIONS
1. WARNS TRUCKS	104	1%
2. YIELDS TO TRUCKS	143	1%
3. WARNS COWORKERS	121	1%
4. YIELDS TO COWORKERS	196	2%
5. SOUNDS HORN AT BLIND INTERSECTION	490	4%
6. SLOWS DOWN AT BLIND INTERSECTION	488	4%
7. LOOKS/BLIND INTERSECTION	465	4%
8. LOOKS IN DIRECTION OF TRAVEL	1819	15%
9. MAINTAINS MODERATE SPEED	1446	12%
10. AVOIDS QUICK STARTS/ CHANGES OF DIRECTION	1100	9%
11. KEEPS ALL BODY PARTS WITHIN TRUCK	1834	15%
12. MAINTAINS FORKS IN PROPER POSITION	1799	15%
13. MAINTAINS BALANCED LOAD	1040	9%
14. DRIVES IN REVERSE	1062	9%
ALL BEHAVIORS	12,107	100%

LIST OF FIGURES

Figure 1. Mean error rates for successive phases of the training program (warehouse 1)

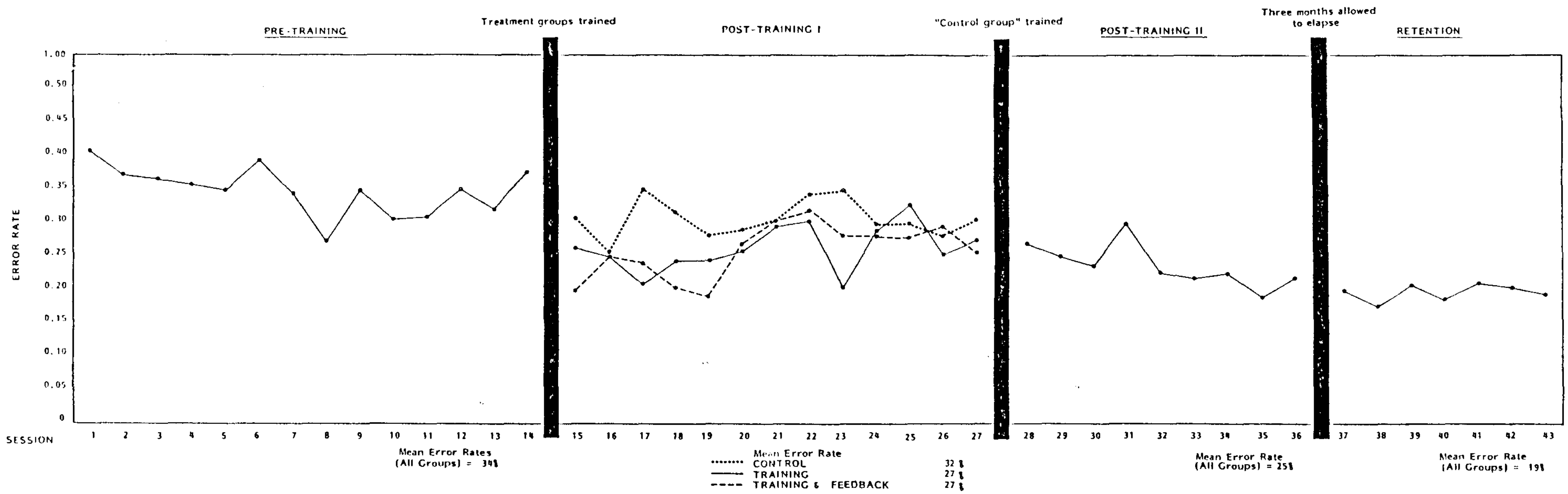

Figure 2. Mean error rates for successive phases of the training program (warehouse 2)

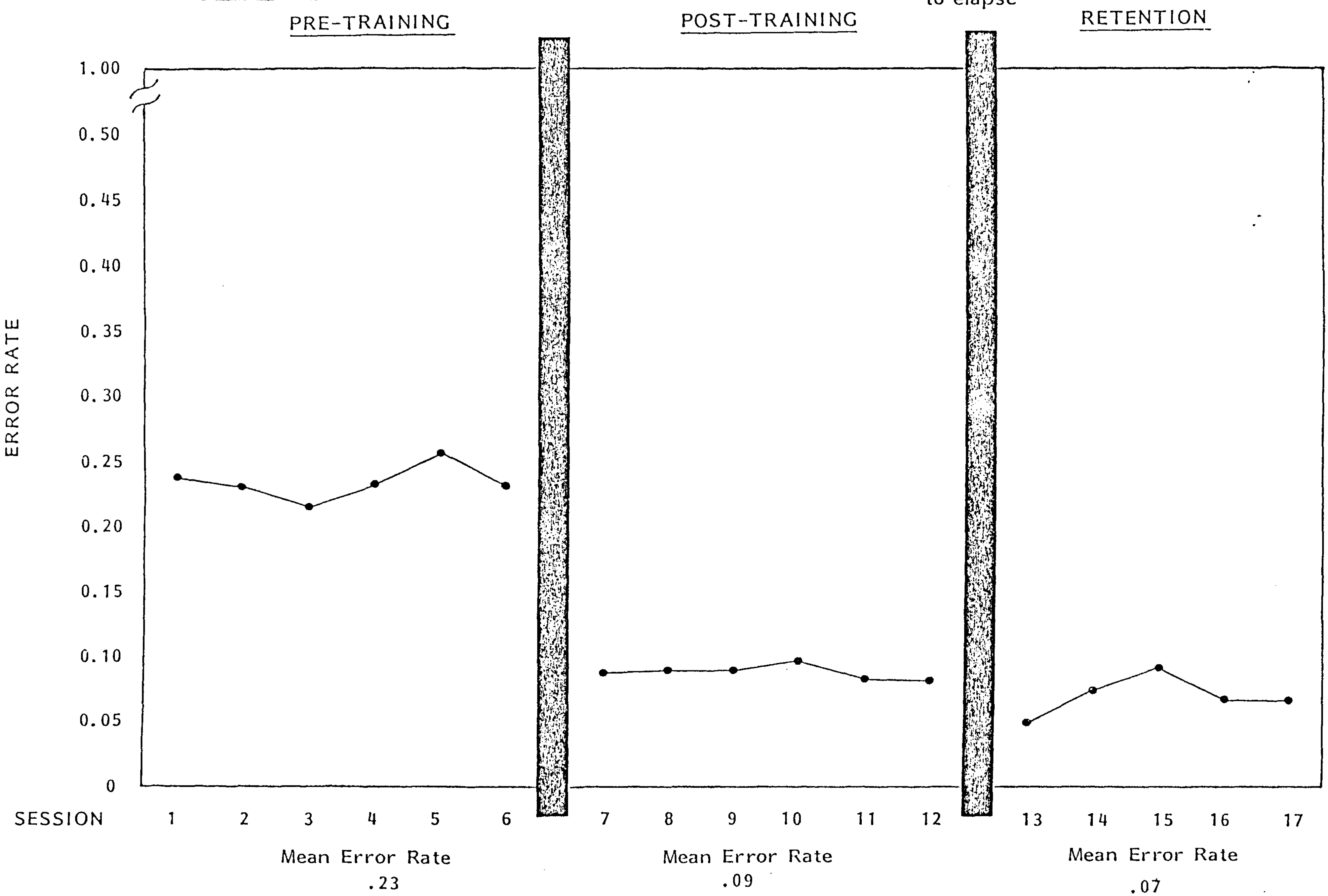

EXHIBIT A

Sample of Draft Job Safety Analysis for Forklift Operators

Tasks	Knowledge and Skills	Consequences
1.0 Walkaround Inspection		
1.1 Checking Oil Level	Observe the oil level dipstick. The level must be between the "full" and "add" marks. Add oil as required.	Failure to check oil level may cause friction wear to engine parts.
	Check that oil is not overfilled.	Too much oil will cause smoking, heavy carbon deposits, foul spark plugs, and over-compression.
	Check for oil leaks.	Spilled oil on the floor may result in slips and falls.
1.2 Checking Radiator Coolant Level	Loosen radiator cap slowly. Remove cap. Observe if level is to the top of the mark on the tank. If low, add coolant.	Failure to check radiator coolant level may cause engine to overheat.
	Relieve pressure by putting a rag over the cap and loosen the cap to the first notch. Wait for pressure to be released.	Failure to relieve pressure slowly may result in severe scalding.
	Check hose for leaks.	Hose leak may result in loss of coolant during operation and slippery driving surface and slips and falls.
1.3 Checking Fuel Level		
1.3.1 Gasoline and diesel	Determine amount needed. Fill tank allowing for expansion with either gasoline or diesel fuel.	Insufficient fuel may result in loss of power and loss of control.
	Wipe up any spilled fuel.	Spilled fuel on the floor may result in slips and falls.
	Check that tank is not overfilled.	Overfilling may result in fire.
1.3.2 LP-Gas	Only trailed personnel may recharge or exchange LP-gas cylinders.	Leaking fuel lines or damaged LP-gas cylinders may result in a fire and/or an explosion.
1.3.3 Battery	Keep battery water level filled to the maximum. Use pure distilled water only.	An inadequately maintained battery will decrease its life expectancy and can cause stalling.
	If splashed with battery acid, wash affected surface immediately with water for fifteen minutes.	Being splashed with battery acid can result in severe burns.
	Provide adequate ventilation.	Inhaling hydrogen gas can be harmful without adequate ventilation.
	No smoking, keep open flames or sparks away from batteries.	Sparking in the area around a battery may result in a fire.

EXHIBIT A (Continued) - Outline of Remaining Tasks and Subtasks

Tasks	Knowledge and Skills	Consequences
1.4 Checking Tires and Wheels		
1.5 Checking Mast, Carriage and Forks		
2.0 MOUNTING AND DISMOUNTING		
2.1 Establishing a Firm Base of Support		
2.2 Checking Hands for Grease		
2.3 Checking Shoes and Steps for Oil and Dirt		
2.4 Stepping Down		
3.0 STARTING PROCEDURE		
3.1 Checking Parking Brake		
3.2 Checking Seat Position		
3.3 Checking Position of Transmission		
3.4 Engaging Starter Switch		
3.4.1 Gasoline powered		
3.4.2 LP-gas powered		
3.4.3 Diesel powered		
3.5 Checking Ammeter		
3.6 Checking Oil Pressure		

EXHIBIT A (Continued)

Tasks	Knowledge and Skills	Consequences
3.7 Checking Temperature Gauge		
3.8 Check Engine Hour Meter		
3.9 Check Hydraulic Oil Level		
3.10 Checking Service Brakes		
3.11 Checking Parking Brake		
3.12 Checking Steering		
3.13 Checking Horn		
4.0 OPERATING CONTROLS		
4.1 Checking Directional Control Lever Position		
4.1.1 Mechanical transmission		
4.2 Checking Speed Control Lever Position		
4.3 Checking Inching Pedal		
5.0 TRAVELING		
5.1 Starting		
5.2 Looking in the Direction of Travel		
5.3 Turning With Rear-Wheel Steering		

EXHIBIT A (Continued)

Tasks	Knowledge and Skills	Consequences
5.4 Checking Elevation of Forks		
5.5 Checking Overhead Clearance		
5.6 Traveling Forward		
5.7 Traveling Backward		
5.8 Giving Rides		
5.9 Noticing Leaks		
5.10 Stopping		
6.0 PICKING UP A LOAD		
6.1 Checking Capacity Rating		
6.2 Approaching Load		
6.3 Adjusting Forks		
6.4 Inching into Position		
6.5 Balancing the Load		
6.6 Raising and Tilting a Load		
6.7 Braking With a Load		
7.0 STACKING		
7.1 Lowering to the Floor		
7.2 Lowering on a Stack		

EXHIBIT A (Continued)

Tasks	Knowledge and Skills	Consequences
8.0 MANUALLY LIFTING MATERIAL ON AND OFF FORKS		
8.1 Positioning Forklift Truck		
8.2 Lifting		
8.3 Team Lifting		
9.0 MANEUVERING ON LOADING DOCKS		
9.1 Driving Along the Edge		
9.2 Driving on Ramps		
9.3 Checking Crossbridge Plates and Dock Boards		
9.4 Checking Dock Floor Conditions		
10.0 LOADING TRACTOR-TRAILERS		
10.1 Checking the Tractor-Trailer Brakes and Wheel Chocks		
10.2 Checking Uncoupled Trailer Supports and Wheel Chocks		
10.3 Checking Floor Conditions		
11.0 LOADING RAILROAD CARS		
11.1 Checking Switching		
11.2 Checking Brakes		

EXHIBIT A (Continued)

Tasks	Knowledge and Skills	Consequences
11.3 Checking Floor Conditions		
11.4 Moving Freight Cars		
12.0 PARKING		
12.1 Checking Location		
12.2 Shutting Down Procedure		
12.2.1 Checking directional control		
12.2.2 Checking forks elevation		
12.2.3 Checking parking brake		
12.2.4 Stopping the engine		
12.2.5 Removing the key		
12.2.6 Checking grade of floor		