A Strategy to Validate Work Practices:

An Application to the Reinforced Plastics Industry

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FOOTNOTE

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SYNOPSIS/ABSTRACT

Most recommendations for work practices appear to be based on common sense rather than an empirical analysis of the value of those practices to reduce exposures. A strategy for validating recommended work practices is presented and applied to a reinforced plastics manufacturing plant. Selected employees were trained to use several work practice behaviors judged likely to reduce their exposures to styrene. Observational data indicated that all of the work practices, with the exception of respirator usage, changed as desired. Indices of personal exposures decreased by up to 74 percent following training for the workers with the greatest exposures and, potentially, the most control over their exposures. The research is presented as a model which could be generally applied to validate work practices and to develop methods by which workers can be trained to participate in their own occupational health protection.

Recommendations of industrial hygiene and occupational medicine commonly include work practices designed to protect people from hazards. Examples may be found in sections on work practices contained in criteria documents published by the National Institute for Occupational Safety and Health (NIOSH)[1,2]. The execution of all work practices is some form of human behavior. Although work practices are widely recommended, rarely have researchers attempted to validate them by demonstrated usefulness to reduce hazards. Moreover, when there have been attempts to validate work practices, the research methodology has not provided for conclusive inferences. In a literature search, the authors found 254 publications that included various recommendations for work practices, but only 8 of them included measures of hazards prior to, and after the practices were recommended. Moreover, the recommended work behaviors were not measured in any of the eight papers which reported reduced hazards. Therefore, it can not be inferred that the use of the recommended work practices was responsible for the reduced hazards.

Fitch, Hermann and Hopkins[3] outlined a strategy for applying technologies of behavioral science to safety problems in 1976. Central characteristics of the strategy are that health-endangering and health-promoting behaviors of workers are involved in individual exposure to hazards, and that technology is available to measure the relevant behaviors, to change them in prescribed ways, to maintain those that are acceptable, and to evaluate the effectiveness of the behaviors to reduce the hazards. The present paper extends that strategy to the validation of work practices, particularly to work-practices designed or selected to control exposures to toxic substances. By including measurement of use of relevant work practices (behaviors) and measurement of associated hazards, the strategy overcomes the inadequacies of methods employed in previous reports, and provides for the relatively complete validation of recommended work practices. To demonstrate the strategy outlined above and the effectiveness of certain work practices to reduce exposures, workers exposed to styrene in the reinforced plastics industry were chosen for study.

Styrene and reinforced plastics manufacturing were convenient for an initial test of the strategy because many examples of human behavior involvement with exposures result from open, person-performed processes and there are a wide range of measurable exposures which could possibly be reduced.

Human subjects exposed to styrene develop irritation of the mucous membranes, particularly those of the eyes and nose. Exposures at 200-300 ppm produce problems with coordination and balance[4]. Styrene can be absorbed readily through the skin as well as from inhaled air[4,5]. The 8-hour time-weighted average (TWA) Federal standard for styrene is 100 ppm[6].

Manufacturing Processes

Manufacturing of reinforced, laminated plastic products, such as those manufactured from styrene-containing resins, typically consists of a series of operations[7]. A mold that has the converse shape of the desired product is cleaned and waxed and then moved to the gelcoat sprayer who sprays a mixture such as pigmented polyester resin and styrene monomer onto the mold with the compressed air sprayer. The compressed air sprayer is similar to a paint sprayer and is constructed to mix a catalyst such as methyl ethyl ketone peroxide (MEK-p) with a resin such as a resin diluted with styrene as it leaves the gun.

When styrene is used as a diluent-reactant it polymerizes with the resin after application to the mold; during this curing process, the mold is set aside to allow the gelcoat layer to harden. After hardening, the cured gelcoat is given a reinforcing lamination of fibrous-glass. The lamination is applied with a second spray gun that shoots a mixture of chopped fibrous-glass, resin-styrene mixture and catalyst. The operator of this machine is called the chop sprayer.

Immediately after application of the reinforcing lamination, additional reinforcement may be built into the part by the integration of wooden or metal members or woven fibrous-glass mats soaked in a resin-styrene-catalyst mixture. The reinforcement is typically bonded to the part with a light spray of the chopped fibrous-glass mixture.

In the next operation, workers using rollers, much like those employed for painting, roll the newly applied lamination to remove gas bubbles from the mixture and to insure that the resin and fibrous-glass are thoroughly compressed and mixed. These workers are called rollout persons.

The molds and parts are again set aside to cure, the parts are removed from the mold, and the mold is inspected and repaired if necessary. The person who performs this latter operation is called the mold repair person.

Although other finishing operations may be performed, and plants differ with respect to floor plans, engineering controls, storage, and equipment, the above described steps are typical and characterize a major portion of the reinforced-plastics industry.

Methods

Cooperation was secured from Labconco, a producer of reinforced plastic laboratory equipment such as fume hoods and bacteriological glove boxes. In obtaining cooperation of the company, there was an understanding that individual workers would have the option to participate as subjects in the study after being told the general purposes of the research.

Determination of High Exposure Areas and Jobs: Momentary air samples (commonly called grab tube samples) were used to determine styrene concentrations. These samples were taken with a Bendix, Model 400, Gastec pump and Zink styrene detector tubes to identify the plant areas and jobs that involved relatively high exposures. This method sampled only small volumes of air (100 ml) over brief periods of time (less than 30 secs) yielding an estimated accuracy of ±25-35%. The high exposure areas, with momentary concentrations ranging from 110-280 ppm, were the two spray booths in which the gelcoat mixture and the resin-chopped fibrous-glass mixture were sprayed onto the molds. Styrene was vaporized and aerosolized as a result of being sprayed and due to the heat produced during polymerization. These two processes appeared to be the source of most of the styrene in the plant. The rollout and curing areas of the plant also yielded relatively high momentary concentrations of styrene, ranging from 70-170 ppm. The two spraying jobs and the job in which the resin-fibrous-glass mixture was rolled out involved not only the greatest momentary exposures for workers, but also the greatest total time of relatively high exposure.

Several jobs, such as repairing molds and touching up blemishes in gelcoat surfaces, occasionally introduced relatively small quantities of styrene into the air. Many jobs, such as those involved in finishing operations, and moving parts from one area to another, introduced no or negligible styrene into the plant. Workers in these jobs were exposed to styrene as a result of the ambient concentrations produced by the styrene-introducing processes described above. These momentary ambient concentrations typically ranged from 2-20 ppm.

From the high exposure jobs, three workers, the gelcoat sprayer, the resin-chop sprayer, and one rollout person, were selected for further study. It was assumed that changes in work practices would have the greatest likelihood of affecting the exposures of these workers. To determine if similar work practices would reduce the exposure of a worker who was primarily contacting styrene only in ambient air, the mold repair person was also included in the sample.

Development of Potentially Useful Work Practices: Detailed observations were made of these four selected workers to identify ways in which their on-the-job behaviors might be resulting in styrene exposure. Three general classes of health-promoting work practices emerged: 1) using appropriate personal protection, 2) avoiding high-exposure areas when not necessary for production, and 3) taking advantage of existing engineering controls. Based on these three classes, the following specific work practice behaviors were defined:

1) Gelcoat and Chop Sprayers:
    a) Using appropriate personal protection
        1) Wearing a respirator when working inside spray booths.
        2) Keeping all skin below the neck, including hands, covered.
    b) Avoiding high exposure areas
        1) Staying out of spray booths except when spraying, transferring or arranging parts.
    c) Taking advantage of engineering controls
        1) Activating booth exhaust ventilation before spraying.
        2) Keeping doors to spray booths closed while spraying.
        3) Placing molds to be sprayed directly in front of, and close to, exhaust ventilation.
        4) Spraying toward the exhaust ventilation.
        5) Turning molds as necessary to maintain a downwind spray direction.
        6) Minimizing overspray on booth floors and walls.
        7) Not directing spray toward self.
        8) Not directing spray toward others.

2) Rollout Personnel:

   a) Using appropriate personal protection

      1) Wearing a respirator while in the rollout area or spray booth.

      2) Wearing a respirator when working inside molds.

      3) Keeping all skin below the neck, including hands, covered.

   b) Avoiding high-exposure areas

      1) Performing rollout in the rollout area, not in the spray booth or curing areas.

      2) Avoiding the rollout area when not working.

      3) Not entering the spray booth while the sprayer is in operation.

   c) Taking advantage of engineering controls

      1) Activating floor fans and directing them toward exhaust ventilation before rolling out.

      2) Staying upwind of the part while rolling out.

      3) Turning molds as necessary to maintain an upwind position while rolling out.

3) Mold Repair Personnel:

   a) Using appropriate personal protection

      1) Wearing a respirator when working with uncured resin.

      2) Keeping all skin below the neck, including hands, covered.

   b) Avoiding high exposure areas

      1) Staying out of the mold repair area, if not working, while curing resin is present.

2) Keeping head at least 12 inches away from uncured resin applications on molds.

3) Keeping resin containers covered at all times.

c) Taking advantage of engineering controls

1) Performing repairs within the mold repair area.

2) Activating floor fans and directing them toward exhaust ventilation, before applying resin to molds.

3) Staying upwind of uncured resin applications.

4) Turning molds as necessary to maintain an upwind position to curing resin.

Measurement of Work Practices and Exposures: Data were collected on Tuesdays, Wednesdays, and Thursdays, for seventeen days, on each of the four selected workers. There was greater absenteeism and more time was devoted to scheduling work and getting machinery operating on Mondays, and Fridays were given largely to plant cleanup. Therefore, data were not collected on these days. The gelcoat spraying job underwent two personnel changes during the six-week period. The first gelcoat employee worked on days one through three, the second on days four through eight and the third on days nine through seventeen.

Five classes of data were taken: behavioral data, styrene exposure data taken from work-duration breathing zone air samples, styrene exposure data from eight-hour breathing-zone and area air samples, and mandelic acid levels taken from urine samples collected at the end of the work shifts.

To establish whether training actually produced any changes in employees' work practices, behavioral observations were conducted throughout each day of data collection. For each worker, the specific work practice behaviors were defined in observable terms. Each worker was watched during the entire day by an observer who had been trained to recognize and record instances of these defined behaviors. However, observational data were not continuously collected throughout the work day because there were times during which work practices could not have affected styrene exposures. Observational data were only taken during the times the four employees worked with curing resin. For example, the sprayers were observed whenever they were spraying or working inside the spray booths, but not when they were taking breaks, assisting with jobs such as mold waxing, or participating in cleanup operations. An observer was positioned close enough to a worker to be able to see well, but far enough away to not interrere with the employee's work. Each observer carried a clipboard and stopwatch. The stopwatch was turned on, and recording began, whenever the employee began working, and was turned off, terminating recording, whenever the employee stopped working for longer than one minute. During each 15-second period of the observation, the observer scored any instances of the targeted behaviors on a behavior recording sheet.

The accuracy of observer recording was tested through frequent cross-observer reliability checks. At unannounced times, a second observer, using the same observation procedures and definitions, would make an independent recording of an employee's behavior, simultaneously with the assigned observer. The two recordings were later compared to determine the accuracy of the observers and the recording procedures. Such observer "reliability checks" were made on an average of 18 percent of all observations, and were conducted during at least 75 percent of the days of the study. Total daily interobserver agreement scores across all observations were 94 percent for observations of the resin-chop sprayer, 98 percent for the rollout person, 97 percent for the gelcoat sprayer and 100 percent for the mold repair person[8]. Additional detail regarding occurrence, nonoccurrence and chance agreement comparisons of the observational data are available from the authors upon request.

To establish whether the recommended work practices had any effect on workers' exposures to styrene vapor, breathing-zone air samples were collected by operating pumps at precisely the same times as the behavioral observations were conducted, that is, only while the employees were actually working with curing resin. This procedure afforded a direct means of assessing the effects of changed work practices on exposure concentrations during the work periods in which work practice behaviors could affect styrene exposures by eliminating those times of the workday when task-specific work practices would not be feasible to help reduce exposures. Operating the pumps only while work with available styrene occurred provided a means to control for effects from variations of production. The amount of time a pump was operated should vary directly with production. Therefore, this measure, unlike an eight-hour sample, should provide an estimate of average exposure relatively free from changes in exposure resulting from production changes.

Several eight-hour breathing-zone samples were collected, beginning with day six, for the resin-chop sprayer and the mold repair person, to provide overall daily TWA's in addition to the work-time exposures. These pumps were worn by the employees throughout the workday, and were turned off only during lunch periods or times when the employees departed the plant.

Eight-hour samples were also taken daily in two areas of the plant which were not directly involved with any of the specific work areas of the participating employees. One pump was located approximately 15 feet outside of the resin-chop spray booth, and the other was located outside the supervisor's office, near the middle of the production area.

Air sampling procedures were supervised by an AIHA-certified industrial hygienist. Air sampling pumps were calibrated daily at a flow rate of 50 cc/min which was monitored regularly and adjusted as necessary. Air samples were drawn into charcoal-filled glass tubes for collection of styrene and analyzed by the Utah Biomedical Laboratory using NIOSH P&CAM method #127[9] with ethylbenzene as an internal standard. Sample results were adjusted for temperature, humidity and atmospheric pressure.

In order to further evaluate the effectiveness of the program, a 100 ml urine sample was collected from each of the participating employees once daily, during the last 30 minutes of the work shift. Urine samples were treated with 1 ml 6 N HCl and frozen within two hours after collection and were analyzed for mandelic acid by high pressure liquid chromatography.

Work Practice Training Procedures: The above data collection procedures were carried out during several baseline or pre-training days. At the end of baseline, one member of the research staff, functioning as a trainer, met once with each worker for ten to fifteen minutes prior to the beginning of a day's work shift. The trainer explained each of the recommended work practices and how each could help to reduce exposures to styrene. If a worker indicated a lack of understanding of a work practice, the trainer demonstrated it for him or her. The trainer remained with the worker for another ten to fifteen minutes, as work was begun, to give feedback on the use of the work practices and to correct any that were not being properly executed. After this initial training, the trainer visited each worker at unannounced times once or twice each day, for only a minute or two, to provide brief encouragement and feedback on the employee's continued use of the new work procedures.

Experimental Design: To provide information on the extent to which changes in data could be attributed to training, as opposed to uncontrolled variables, not all workers were trained at the same time. After baseline data had been collected on all four workers for eight days, training was introduced for two workers, the resin-chop sprayer and the rollout person. Pre-training data collection was continued for the gelcoat sprayer and mold repair person for the next three days, before they, in turn were trained. This experimental design allowed for a number of important comparisons.

Effects of training could be inferred from changes from baseline to post-training data. In addition, the fact that the gelcoat sprayer and mold repair person were not trained until after the other two workers, allows their data to serve as controls for the data of the first-trained workers for three days. For example, if any changes in the data of the first-trained workers should be attributable to uncontrolled variables such as changes in plant policies or weather, these factors might also be reflected in changes in data of the workers who were not yet trained. Finally, the fact that the workers were trained at different times provides a test of the extent to which the training procedures were effective to produce repeatable results at different points in time. This design, called a multiple baseline design, is frequently used in behavioral experiments[10,11]

Results

Table 1 displays the percent of 15-second observation intervals in which each of the targeted behaviors occurred during the baseline period and following training. With few exceptions the behaviors changed as desired. The exceptions included several practices which were

already occurring at acceptable levels, e.g., the chop-sprayer's spraying toward himself and turning on the booth exhaust. Wearing a respirator while working with resin was not adopted by the chop sprayer even though it was a highly desirable work practice. Training apparently induced slight increases in the percent of time the chop sprayer, the rollout person, and the gelcoat sprayer were in their work areas but not working. This may have been due to the time required to arrange and turn molds. The extent to which the number of data points, during baseline and after training, deviated from the mean of all data points in the desired direction was compared to the number expected by chance according to a binomial distribution[12]. The probabilities that such results, for each work behavior, would be obtained by chance are presented in the right column of Table 1.

Figure 1 includes graphed data of the percent of observation intervals in which the resin-chop sprayer and the gelcoat sprayers placed molds in the spray booths properly, during baseline and after training. During baseline, the rate of correct mold placement was low for both the chop sprayer and the gelcoat sprayers. When training was given to the chop sprayer on the ninth day of data collection, his rate of correct mold placement increased immediately while that of the gelcoat sprayer remained low until he was trained one week later. Figure 1 provides a representative example of the way in which the data of the gelcoat sprayer and mold repair person served as a control for those of the chop sprayer and rollout person during days nine, ten, and eleven of data collection. In all cases in which the work practices changed as desired, the percent of intervals in which they were occurring remained relatively stable throughout the baseline period before changing with the introduction of training. The fact that training, and the changes of the behaviors, did not occur for the gelcoat sprayer and the mold repair person until a week after they occurred for the chop sprayer and rollout person is a good indication that the behavior changes were caused by training rather than by some unmeasured confounding. The fact that the behaviors of the gelcoat sprayer and the mold repair person generally changed, as had the behaviors of the chop sprayer and rollout person one week before, once training began for them, is a good indication that the effects of training are replicable.

The behavioral data, when displayed as in Figure 1, also provide an index of the rapidity with which the various work practices can be induced. It can be seen that the changes in the percent of intervals in which the resin-chop sprayer and gelcoat sprayer placed molds properly in the spray booths occurred almost immediately with the beginning of training. This was true of most of the work practices that changed as desired. Exceptions were the chop sprayer's working with uncovered skin, overspraying and having the booth doors open while working; the rollout person's working outside the rollout area; and the gelcoat sprayer's working with skin uncovered and spraying toward himself. In the cases in which the workers' behaviors changed gradually, anywhere from one week to almost three weeks was required for the full extent of change to occur.

The daily personal styrene exposures for all four subjects, taken during the times they were working as defined above, during baseline and after training, are presented in Figure 2. The exposure of the chop sprayer decreased from a mean of 150 ppm during baseline to 96 ppm after training, a decrease of 36 percent; the rollout person from 121 ppm to 70 ppm, a 42 percent decrease; and the gelcoat sprayers from 210 ppm to 91 ppm, a 57 percent decrease. A statistically unreliable eight percent decrease in mean personal exposure occurred for the mold repair person. The significance levels of the reductions in exposure, calculated according to binomial probabilities, were 0.02, 0.01, and 0.02 respectively for the chop sprayer, the rollout person and the gelcoat sprayer.

Decreasing trends occurred in the personal samples of the chop sprayer and the rollout person during baseline. However, the daily exposures during this time very closely correlated with production. The correlation suggests that production was simply introducing less styrene into the plant rather than that these two workers were becoming less exposed to available styrene during baseline. This also suggests that the method of only operating the breathing zone pumps during time worked only partially controls for variations of exposure due to changes in production.

There were immediate changes in exposures, following training, for the two sprayers and the rollout person even though the production schedule was increased. The new levels of personal exposures remained relatively stable throughout the post-training data collection.

The eight-hour personal samples and eight-hour area samples indicate that exposures were well below the Federal standard. The personal samples ranged from a low of 28 to a high of 54 ppm styrene, with a mean of 41 ppm, for the chop sprayer, and from 3.2 to 13, with a mean of 7.5 ppm, for the mold repair person. General area samples ranged from 0.10 to 12 ppm.

Urine mandelic acid levels did not decrease for all workers following training for the recommended work practices. Micrograms of mandelic acid per milligram of creatinine were divided by minutes worked because the amount of available styrene, and consequently the concentration of mandelic acid in the urine is in part dependent on duration of exposure. This index decreased from a mean of .66 during baseline to a mean of .17 after training (binomial $p < .002$) for the gelcoat sprayer and from .46 to .30 (binomial $p < .03$) for the rollout person. There was no change for the mold repair person just as there was no change in his styrene exposure. A slight increase in this index for the chop sprayer may be explained by the decreases in exposure concentration being counteracted by increased exposure times.

Discussion

The training technology was sufficient to induce the desired changes in most of the work practices and these were correlated with 36 to 57 percent reductions in exposures to styrene vapor during the times measured for the three workers who were receiving the greatest breathing zone exposures. That there was little reduction of exposure for the mold repair person was not surprising. A great portion of his exposure appeared to result from styrene introduced by processes in other parts of the plant. Little of his exposure appeared to result from his occasional and brief work with styrene. Therefore, only a small percentage of his total exposure could be avoided by his own work behaviors with the exception of wearing a respirator.

Mandelic acid levels have been reported to be highly correlated with exposures to styrene,[13,14,15,16,17] and they have the potential to reflect ingested or percutaneously absorbed styrene as well as that inhaled. Only the data for the gelcoat sprayer and rollout person reflect a consistent change in mandelic acid levels. It is possible that these effects are apparent because of the magnitude of the change in their exposure, and their use of respirators.

The striking reduction in mandelic acid of the gelcoat sprayer likely resulted from his training-induced use of a respirator, the only work practice he, but none of the other workers, adopted during a substantial percentage of time worked with curing resins. This suggests that wearing a respirator may be an important work practice whenever high exposures can not be reduced by engineering controls or other work practices. In turn, this observation highlights the importance of the difficulty in getting some workers to wear respirators. The chop sprayer declined to wear a respirator at all times and the rollout person generally used one only when working inside a mold.

The training carried out by the senior author was sufficiently simple and straightforward that it could be done by plant personnel. It should be observed that none of the work practices were particularly complex and all workers probably already had the necessary behaviors in their repertoires. Therefore, training was a matter of prompting the workers to engage in the behaviors. Once the behaviors were occurring, there was, similarly, little difficulty in maintaining them for at least three weeks. There has been general skepticism that workers will reliably engage in protective behaviors over long periods of time. It remains to be seen to what extent this is correct in the present case.

The greatest difficulty in validating work practices by measuring the extent to which they reduce exposures will probably result from the fact that there are many other variables that will contribute to the amount of toxic substances introduced into plant environments. In the present research these variables included such things as the ratio of styrene to resin in the materials supplied to the plant, the amount of catalyst introduced in the spraying operations, the sizes and shapes of the parts being produced, and the weather. These variables will change from day-to-day and will, thereby, produce variations in exposure levels. Such variations in exposures will tend to hide effects that result from changed work behaviors. In addition, whenever reductions of exposures are correlated with changed work practices, there can be questions about whether the reduced exposures result from the work practices or from unknown changes in the many other variables.

In the reported research, the major variation in styrene levels probably resulted from changes in rates of production. Sales demands, breakdowns and numbers of workers present sometimes interacted so that production, and the amount of styrene introduced into the environment, might vary by a factor of two or three. For the purposes of this experiment, controlling the rate of production was not reasonable because it would have interfered with the company's business. Therefore, this factor had to be controlled by some rational adjustment of data. The adjustment took the form of keeping sampling times proportional to production and weighting mandelic acid data by the reciprocal of time worked with curing resin. These adjustments appear adequate for the exposure data, but partially successful for the mandelic acid data.

If such measurement problems in estimating exposures can be solved - and they must be solved to provide empirical bases for all approaches to reducing exposures to toxic substances - the technology to validate work practices would appear to be broadly applicable. Once potentially useful practices are identified, observational definitions and recording methods can be developed and the reliability of the measurement determined at least for a large class of practices. This allows for the examination of the extent to which workers' behaviors change as prescribed. If appropriate measures of exposure change, as desired, with changes in the behaviors, and particularly if this correlation is replicated over workers, the usefulness of the work procedures can be determined. The technology would appear to be sufficiently flexible to examine the effectiveness of collections of simultaneously introduced work procedures, as was done in the present case, or it could be applied to validate a single work practice such as vacuuming rather than blowing dust which contained asbestos fibers[18,19].

If the technology is applied to collections of work practices, it is impossible to infer, from positive results, that a single work practice contributes to the overall reduction in exposures. However, this may not be a serious loss of information unless some of the work practices are so difficult to implement that including them in the package endangers the acceptance of the other practices.

Analyses of the behavioral and exposure data will allow for determinations of the ease with which work practices are adopted and are useful for different workers within a single plant, the extent to which different practices are adopted and are useful within different plants in a single industry, and the generality of usefulness of work practices over different industries. As work practices are validated, they can be incorporated into training programs. If necessary, motivation programs can be developed to encourage workers to use effective work practices. The research strategy used to validate work practices will also be directly applicable to building an empirical base for worker training and motivation programs. Measurement of worker behaviors and exposures will provide benchmarks against which the effectiveness of training or motivation technologies can be compared and the only means to validate the programs that are developed.

There has been recent emphasis on the importance of human behavior in protecting workers from exposures to toxic substances[20]. The lack of a technology to successfully influence behavior has been noted to be crucial. For example, Dr. Anita Bahn[21] has stated,

> "...in general, modification of individual behavior so as to reduce personal hazards is the principal impediment...

(in the industrial setting) today" (p.12).

It is our opinion that much of the pessimism about the prospects of influencing behavior has resulted from cases in which there have been failures to produce desired behaviors because: 1) training has amounted to little more than simple communication of information; 2) training methods have not routinely included the extended follow up necessary to alter existing habits; or 3) little attention has been paid to the importance of motivating the person being trained. Training and motivation technology can be made arbitrarily powerful. In some cases, that power can be achieved without undue expense and complexity. In all cases, an appropriate strategy to validate proffered work practices is at hand.

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TABLE 1

THE MEAN PERCENT OF INTERVALS OF OCCURRENCE OF EACH OF THE WORK BEHAVIORS DURING BASELINE (BL) AND AFTER TRAINING (TR), FOR EACH OF THE FOUR WORKERS AND PROBABILITIES (p) OF OBTAINING SUCH CHANGES BY CHANCE. N.S. INDICATES THAT THE CHANGES WERE NOT STATISTICALLY SIGNIFICANT.

Chop Sprayer	BL	TR	p
Wearing respirator while inside spray booth	0	0	N.S.
Keeping skin covered	24	76	<.03
Staying in spray booth when not working	5	12	N.S.
Activating booth exhaust ventilation	100	100	N.S.
Keeping booth doors closed while spraying	42	93	<.10
Placing molds properly	8	93	<.001
Spraying toward exhaust ventilation	70	99	<.001
Turning molds	2	4	<.04
Overspraying unnecessarily	15	4	<.03
Spraying toward self	.3	0	N.S.
Spraying toward others	23	2	<.001

(TABLE 1 CONTINUED)

Rollout Person	BL	TR	p
Wearing respirator while working with uncured resin	0	4	<.01
Working inside molds without respirator	4	.2	<.01
Keeping skin covered	3	98	<.001
Performing rollout in rollout area	4	93	<.001
Remaining in rollout area when not working	2	3	N.S.
Exposing self to resin spray	13	0	<.001
Using floor fans properly	11	98	<.001
Staying upwind of part while rolling out	50	94	<.001
Turning molds	0	1	N.S.

Gelcoat Sprayer	BL	TR	p
Wearing respirator while inside spray booth	2	99	<.03
Keeping skin covered	0	89	<.03
Staying in spray booth when not working	9	10	N.S.
Activating booth exhaust ventilation	99	100	N.S.
Keeping booth doors closed while spraying	2	97	<.03
Placing molds properly	10	94	<.03
Spraying toward exhaust ventilation	58	97	<.03
Turning molds	1	7	<.03
Overspraying unnecessarily	10	3	<.10
Spraying toward self	1	.2	N.S.
Spraying toward others	0	0	N.S.

(TABLE 1 CONTINUED)

Mold Repair	BL	TR	p
Wearing respirator while working with uncured resin	0	0	N.S.
Keeping skin covered	92	99	N.S.
Remaining in repair areas when not working	9	6	N.S.
Holding head too close to resin applications	6	3	N.S.
Leaving resin containers uncovered	4	3	N.S.
Performing repairs within the repair area	76	95	<.05
Using floor fans properly	1	100	<.05
Staying upwind of uncured resin applications	55	97	<.05
Turning molds	0	.3	N.S.

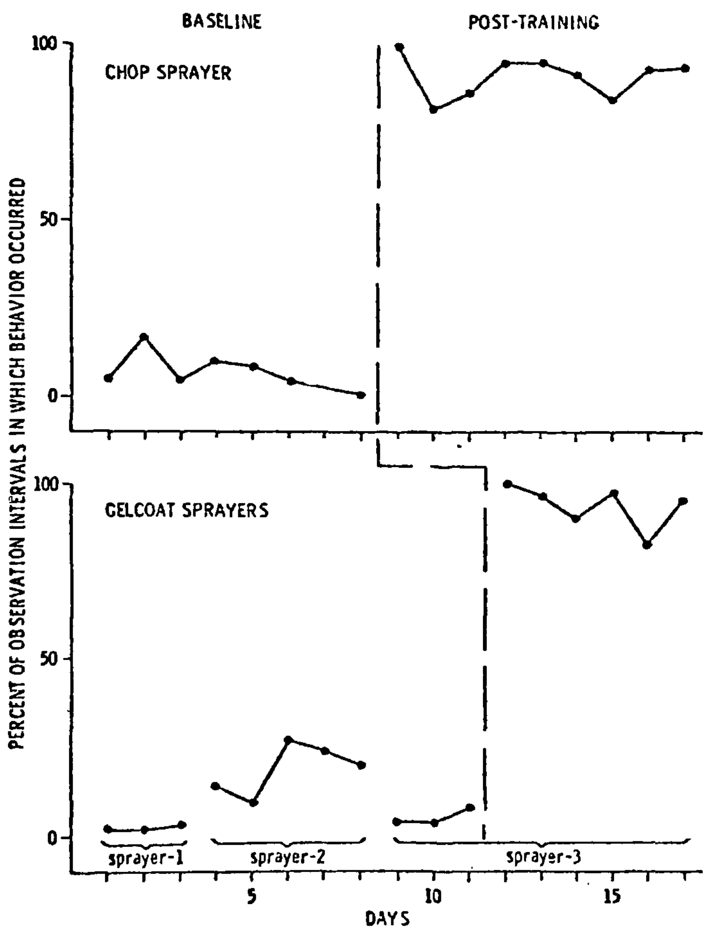
BASELINE
POST-TRAINING
CHOP SPRAYER
GELCOAT SPRAYERS
PERCENT OF OBSERVATION INTERVALS IN WHICH BEHAVIOR OCCURRED
100
50
0
sprayer-1
sprayer-2
sprayer-3
5
10
15
DAYS

Figure 1

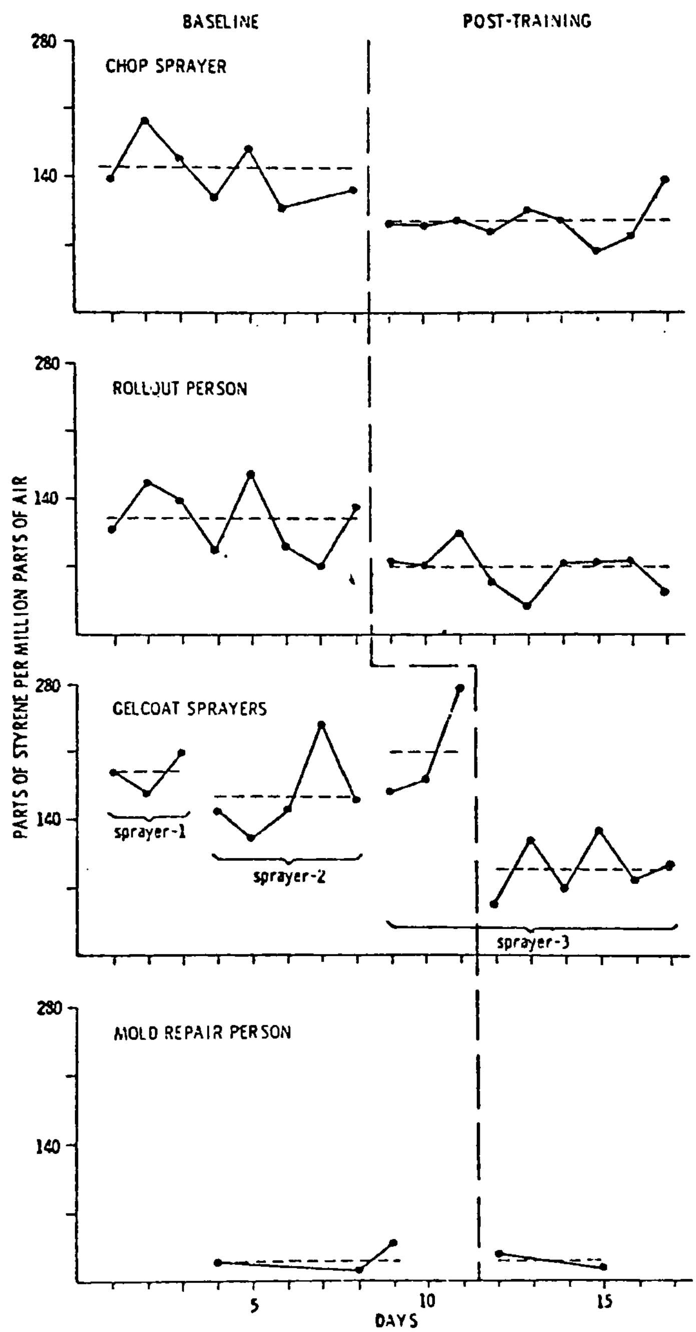
BASELINE
POST-TRAINING
280
CHOP SPRAYER
140
280
ROLLOUT PERSON
140
PARTS OF STYRENE PER MILLION PARTS OF AIR
280
GELCOAT SPRAYERS
140
sprayer-1
sprayer-2
sprayer-3
280
MOLD REPAIR PERSON
140
5
10
15
DAYS

Figure 2

National Cancer Institute

PROCEEDINGS OF THE FIRST NCI/EPA/NIOSH COLLABORATIVE WORKSHOP: PROGRESS ON JOINT ENVIRONMENTAL AND OCCUPATIONAL CANCER STUDIES

MAY 6-8, 1980

SHERATON/POTOMAC, ROCKVILLE, MARYLAND

The papers included in these Proceedings were printed as they were submitted to this office.

Appropriate portions of the discussions, working groups and plenary session were sent to the participants for editing. The style of editing varied, as could be expected. To the extent possible, we have attempted to arrive at a consistent format.

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Proceedings were developed from a workshop on the National Cancer Institute's, the Environmental Protection Agency's and the National Institute for Occupational Safety and Health's Collaborative Programs on Environmental and Occupational Carcinogenesis.

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