[1]BEHAVIORAL SAFETY PROGRAMS IN THE DEPARTMENT OF ENERGY

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Behavioral safety is the application of reinforcement theory to foster an increase in "safe behavior." The process starts with a behavioral hazard analysis to identify unsafe workplace behaviors. A checklist is then developed to assist in the observation of work behavior. Safe and unsafe behaviors are recorded and provided as feedback (reinforcement) to the worker, which increases safe behavior leading to continuous improvement and worker involvement. Developed in the late 1970s, behavioral safety has an impressive track record. Research has shown that as safe behaviors increase, safety incidents decrease. Within the Department of Energy, behavioral safety has been instituted at industrial sites such as the Savannah River Site (SRS) and the Strategic Petroleum Reserve (SPRO), and at national laboratories such as Los Alamos National Laboratory (LANL), Idaho National Engineering and Environmental Laboratory (INEEL) and Lawrence Berkeley Laboratory (LBL). In all cases, implementing the behavioral safety process has led to an increase in safe behavior and a decrease in overall safety incidents.

Many studies have shown that a major cause of workplace accidents is unsafe behaviors. Heinrich (1959) indicated that almost 90 percent of all safety incidents are due to these behaviors. Reason (1997) discusses many of the bases for these unsafe behaviors. A variety of factors have been indicated, such as poor design, supervisory factors, procedure failures and taking shortcuts. In time, unsafe behavior becomes embedded in the conduct of operations, because the consequences of failure are rare. Traditional safety programs, such as engineering changes, administrative controls and personal protective equipment have been used for years in dealing with safety "shortfalls." While these approaches have made for a safer workplace, accident data and presentations at major conferences indicate that safety performance is still not at the level desired by workers, unions or management.

In 1978, Komaki, Barwick and Scott first applied reinforcement theory to the problem of safety. They showed that behavioral observation and feedback could effect behavior; an increase in safe behaviors from 75-80% to 95-99% was found. The feedback given was positive, which elicited positive reactions from the employees as well as their supervisors. Komaki et al. demonstrated a positive impact on safe behaviors, but the initial study did not link this increase in safe behaviors to actual safety measures. Sulzer-Azaroff (1978) and Sulzer-Azaroff and Santamaria (1980) demonstrated that when safety hazards are identified, and positive feedback is used following hazard inspections, the number of hazards is reduced. The implication is that the fewer the hazards, the safer the workplace. It was left to Reber and associates (Reber, Wallin & Chhokar,1983; Reber & Wallin, 1984) to relate safe behaviors to different safety measures. They found the correlation with the overall injury rate was r= -0.85 with a lost-time injury rate of -.0.69. The negative correlation indicates that as the percentage of safe behaviors increase, injuries decrease. A 1993 survey offers a comparison of different safety interventions as shown in Figure 1 (Guastello, 1993). Guastello presented his data in terms of percentage injury reduction and reported the effect of such traditional safety interventions as engineering (29% reduction), management audits (19%), poster campaigns (14%), near miss reporting (0%), but reported 51.6% due to "comprehensive ergonomics" (European definition) and 59.6% due to behavior modification (behavioral safety). It appears that the behavioral safety approach is attacking a different aspect of the safety problem.

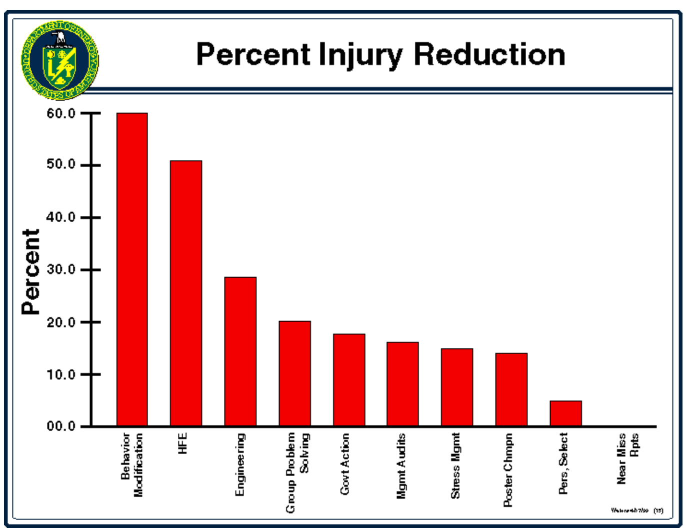

Figure 1. Percent injury reduction due to different safety program interventions. (Guastello, 1993)

[1] Presented at the 45th Annual Meeting of the Human Factors Society, Minneapolis, MN October 9, 2001

The Behavioral Safety Process.

The behavioral safety process is illustrated in Figure 2.

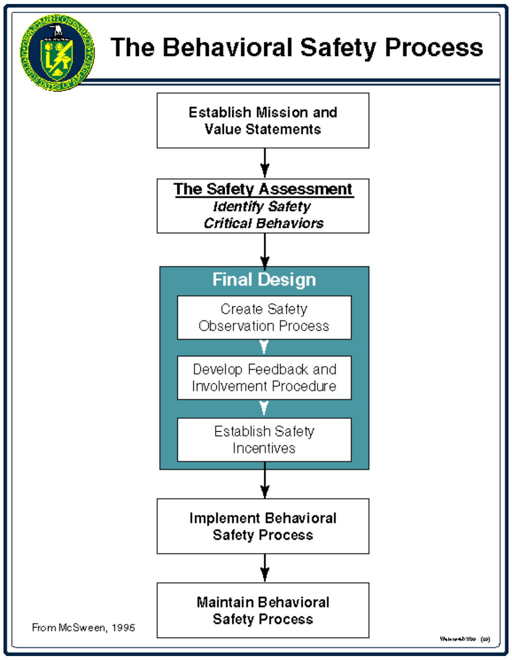

Figure 2. The basic behavioral safety process (From McSween, 1997)

Establishing the Mission: As with any process, its scope and mission should be determined early on. Behavioral safety has the advantage of being adaptable to mission and safety problems in your workspace. The first stage is to identify problem areas, the resources needed and available, and then prioritize. Behavioral safety processes can be very limited in scope. INEEL did a pilot project where peoples' behavior on stairs was observed and recorded. The same people were then provided feedback about the importance of holding the handrail. Geller (1984) provided feedback and incentives for wearing seatbelts. On the other hand, the Dyn-McDermot Corporation at SPRO instituted a comprehensive program dealing with all workplace aspects. For any type of project, particularly the important ones affecting the industrial dynamic, it is important to get support from both labor and management.

Safety Assessment: The core of the technical aspects of behavioral safety is the safety assessment, which identifies the "Safety Critical Behaviors." This assessment can be done in many ways including traditional human factors hazard analyses, brainstorming, or using walkthrough/talkthrough methods. In practice, however, the most common input to the safety assessment is lessons learned. Because of the failure of many incident assessment techniques to adequately evaluate the root cause of human error incidents, most of these causes still exist even after multiple accidents. The occurrence of an accident predicts it can happen again. This can form the basis of a safety assessment.

Design of the Process: The safety assessment helps identify behaviors, which can cause accidents. Using these behaviors, a checklist is constructed for observing behaviors. In theory, this checklist can be as long as needed or as short as feasible to accomplish a thorough review. Because this is a learning problem, stimulus generalization occurs, which covers behaviors not usually involved such as safety in the home. Once the checklist has been developed, it must be determined how it will be used. This includes who observes, how often they occur, and how feedback is given. There are many variations. For example, in many locations the observers are peers, but if trust is present, supervisors may observe. Feedback is normally given to the individual observed, but may also be given periodically as the average percentage of safe behaviors. The more frequent the observation, the quicker the results.

Implement the Behavioral Safety Process: The easy part of behavioral safety is now over. To implement behavioral safety, observers will need to be trained, both to use the checklist and to provide feedback in a positive manner. Observation needs to be started before feedback in order to establish a baseline level of behavior (safety data is normally already collected as the Occupational Safety and Health Administration [OSHA] requires). Observation and feedback begins and the data is used to calculate a measure of performance, often called the Safe Behaviors Index or percentage of safe behaviors in order to provide process feedback.

Maintain Behavioral Safety Process: Behavioral safety is not something done once and then forgotten. If the process of feedback (reinforcement) is not maintained, behavior reverts to the original level. The original report by Komaki et al. (1978), contained data where observations were made several months after the study was halted. It showed that behavior had reverted back to the original levels. This effect is so pronounced that Ray, Purswell, and Bowen (1991) indicated a failure of long-term effects of the safety process. What seems to be missing from behavioral safety literature is an understanding of the extinction process found in many reinforcement theories. The research findings indicate that if reinforcement is not provided, the response ceases.

Department of Energy Results

Behavioral safety showed results quickly. Los Alamos National Laboratory has a relatively new program, yet in Figure 3, they have improved from an 82% safe behaviors rate to 92%. It is yet to early to determine the impact of behavioral safety on their recordable accident record, (e.g., number of injuries, total recordable cases [TRC] etc.). At the SRS, which has a mature program, there was a significant decrease in the number of injuries as the percentage of safe behaviors increased, see Figure 4. While the percentage of safe behaviors rose only slightly, from 89 to 95%, there was a two-thirds reduction in the OSHA TRC, from 1.8 to 0.65.

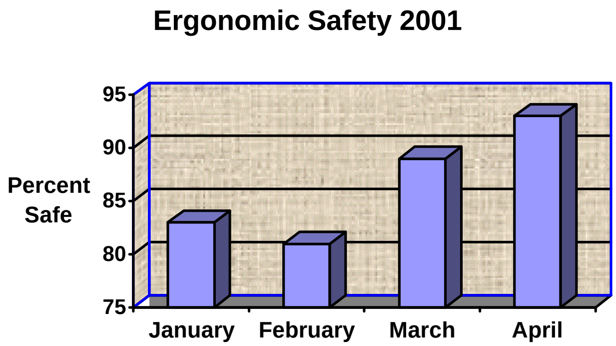

Figure 3. Trend in Observations of Safe Behavior at the Los Alamos National Laboratory.

Figure 4. Site Utilities Department, %Safe Behaviors and Total Recordable Cases.

At the Savannah River Site, the behavioral safety process was instituted in the Site Utility Department in 1996, over the several years of operation, they showed a gradual increase in %Safe behaviors as shown in Figure 4. This went from 89% to 95%, with a decrease in variability, which is an indication of a maturing process.

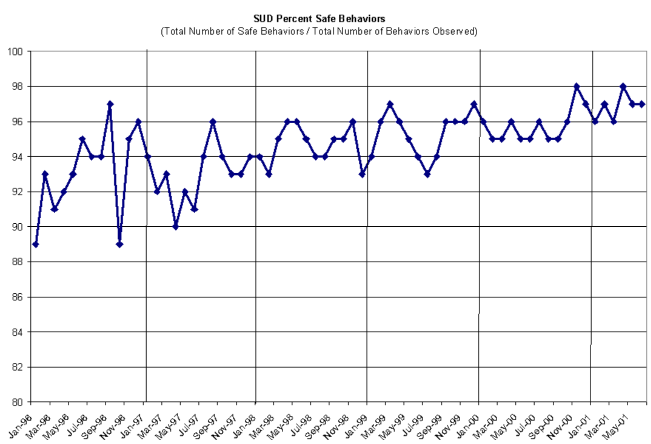

Figure 4. Percentage Safe Behaviors at SRS Site Utilities Department (Duncan 2001)

This was already a very safe site, but TRC was reduced from a level of about 1.7 to zero during this period (Figure 5).

The Dyn-McDermot Corporation at the Strategic Petroleum Reserve found that the number of observations (reinforcements) was an important factor in increasing safe behavior and reducing injuries. This program has already driven %Safe Behaviors to the maximum, approaching 100%, so they look at the date somewhat differently. As shown in Figure 6, they plot observations against TRC rate, and have found that as the number of observations increases, the TCR decreases. SPR provides immediate positive feedback after each observation, therefore the more behavioral observations the more reinforcements.

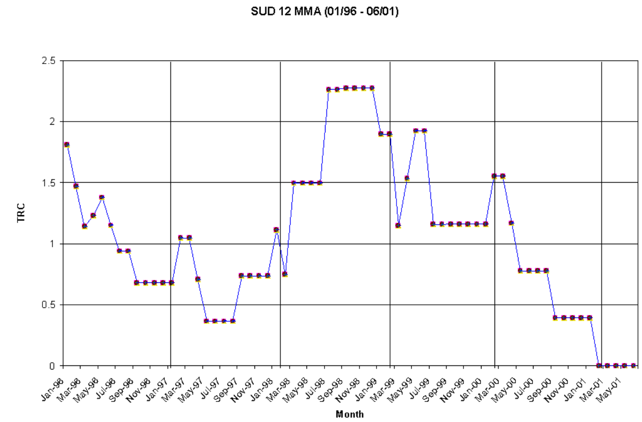

Figure 5. SRS TRC Rate Changes Due to the Behavioral Safety Process.

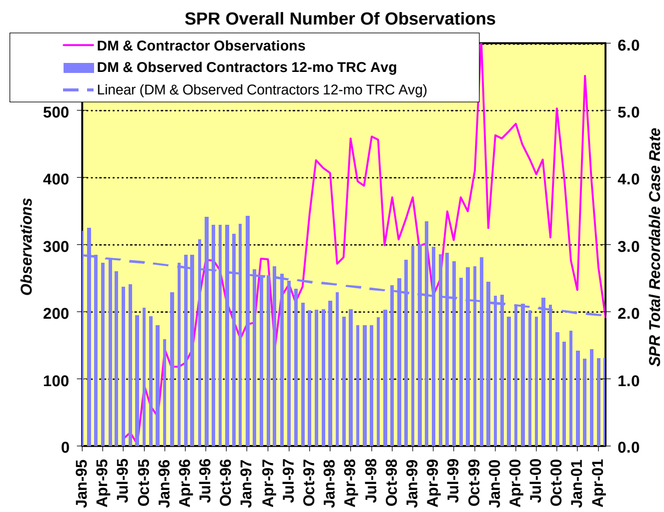

Figure 6. Strategic Petroleum Reserve Behavioral Safety Results (1995-2001)

Lawrence-Berkeley Laboratory (Chung, 2000) took another path evaluating the BBSP: Cost-effectiveness. The total cost of implementing BBSP was $230,000. Considered in the evaluation were the personnel cost factors such as health and safety, personnel time for accident investigation efforts, added to them the effects of production costs from injuries and illnesses, considering such factors as employee downtime for accident response, stopped work production, medical care, lost time and restricted duty. Also considered were legal and medical costs, including workmen's compensation costs and management costs, medical and insurance costs. The pre-BBSP TRC rate was 31, and this was reduced to 23 in the first year and 22 in the second year. The identified costs for each incident before BBSP was $33K and this was reduced after BBSP to $28K. With the reduction in TRC, this led to savings of $648,000 for the first two years. The benefits are shown in Table 1.

Table 1. Lawrence-Berkeley Laboratory: Behavioral Safety Benefits Calculated

Metric	Result	Comments
Payback Period	0.6 years	Recovered $230,000 in BBSP program costs within 7.2 months.
Net Present Value	$648k	Generated $648,000 in lost prevention savings from BBSP implementation (50% from workers Compensation program)
Return on Investment	281%	Created an investment return from BBSP that nearly <u>triples</u> the initial program outlay of $230,000

Conclusions

In many industrial settings, accident and reportable rates are still above what OSHA or the industry requires. This reduction has mainly occurred in settings where engineering controls, normal administrative controls (e.g. procedures, SOP's, warning signs) and even personnel protective equipment have been used and have been effective, but the rates remain unchanged. It seems evident that some other type of safety intervention is called for. In 1971, Skinner called for a technology of behavior, behavioral safety appears to be the missing piece of the safety puzzle that has been eluding human factors and safety personnel.

Behavioral modification in the form of the Behavior Based Safety Process can be an effective safety intervention. After two decades of use, primarily in industrial settings, behavioral safety has consistently reduced injuries and other events. These reductions have been in the range of 30 to 70% and the return on investment, as reported by Chung (2000) is significantly less than the return. As effective as it seems to be, behavior based safety, however, still uses a relatively primitive version of reinforcement theory. The theoretical basis of the theory is Skinner's 1938 version which does not deal with many factors that have shown to impact behavior such as, magnitude of reinforcement, varied reinforcement schedules, sequences of reinforcement, and resistance to extinction. Modernizing the theory and adapting these more modern factors to the process may be able to produce even more spectacular results.

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