Safety Management

Behavioral Safety in a Refinery

Large-scale change and long-term results

By Rixio E. Medina, Terry E. McSween, Kristen Rost and Alicia M. Alvero

PETROLEUM REFINING PRODUCES large volumes of air, water, and solid and hazardous waste that can pose health risks to workers and neighboring communities. Workers are at risk for serious injuries and illnesses resulting from fires, explosions, chemical spills, heat exposure, polluted air and carbon monoxide exposure (O'Rourke & Connolly, 2003). In 2006, approximately 112,000 U.S. workers were employed in the petroleum and coal products subsector of the manufacturing industry. That year, the subsector experienced nine fatalities, four of which occurred in petroleum refineries, and had a rate of 2.7 recordable injuries and illnesses per 100 full-time workers (Bureau of Labor Statistics, 2008).

Behavioral safety systems have been implemented in manufacturing settings, often to reduce the risks of injuries, illnesses and fatalities, and to support and maintain safe work practices (Grindle, Dickinson & Boettcher, 2000). The components of these systems vary across applications, but some common components are to pinpoint work practices that affect safety; define and reliably measure such practices; implement measurement systems; set reasonable goals; and provide performance feedback and reinforce progress. These elements are often used in combination with ergonomics, training, and occupational health and safety management (Sulzer-Azaroff & Austin, 2000).

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This article describes the implementation of a behavioral safety process at CITGO Petroleum Corp. CITGO owns and operates three oil refineries in the U.S. with a total petroleum processing capacity of approximately 760,000 barrels a day. Initial implementation began with the petroleum refinery in Lake Charles, LA. The site consisted of six self-contained operation areas with a total employment of about 1,465 people.

Before implementation, plant management had a clear mission to reduce injuries and change the work culture to one that demonstrated value for safe and healthy employees. Employee safety teams were formed in the late 1980s to improve safety in the plant. As with many traditional safety methods, teams were rewarded for time without an incident, but these efforts did not have a clear effect on safety practices. In 1994, behavioral safety consultation was sought to help managers achieve their safety mission.

Process Implementation

In 1994, the multistage implementation began in the power thermal area of the refinery, selected as the pilot group because it had a high rate of serious injuries, was considered resistant to new initiatives, and involved some of the most strenuous and hazardous work tasks in the plant. In 1992 alone, the area had three lost-workday incidents and five recordable injuries. At the time of implementation, the power thermal area had about 189 employees.

Stage 1: Safety Assessment & Team Development

Consultants conducted a safety assessment by guiding an injury analysis that was completed by a team of employees and interviewed personnel. Consultants conducted face-to-face interviews with

Table 1

Sample Work Practices Identified

Work practice	Definition
Equipment de-energized and use of locks and tags	Equipment has been de-energized of all types of power, including mechanical, hydraulic, thermal, electrical and compressed gas. Includes draining and blinding lines that may be under pressure. Lines are shut down before attempting to clear jams or effect repairs. Locks and tags are properly used to prevent releases of hazardous energy (including mechanical, hydraulic, thermal, electrical and compressed gas).
Work areas free of slip or trip hazards	Walkways and work areas are clean and free of spills and clutter that might contribute to slips, trips or falls. Electrical cords and air hoses are coiled and stored when not in use. Yellow and black tape is used to identify slip, trip or bump hazards, water on floor, extension cords or air hoses.
Hot surfaces insulated	Hot piping and equipment are covered with insulation for personal protection (up to 6 ft and in areas where contact is possible).
Eyes on path or work	Face and head generally pointed in the direction of travel. Not walking while looking up or down, or talking to others. Watching hands, tasks and immediate work area.
Proper body position when lifting, reaching, pushing, pulling or carrying items	Position body close to load, maintain natural curve in lower back, use mechanical lifting devices when possible, get help when not sure of load or with heavy or bulky load. Square up to task (do not twist at waist). Consider risk of repetitive motion injury and discuss body breaks when appropriate. Get proper leverage for use of arms or legs, not back, for pulling, and do not try to lift or pull from extended reach. Push rather than pull whenever possible.
Protective clothing	Clothing appropriate for task (chemical suits, slicker suits, rubber boots) and protective clothing worn properly (sleeves rolled down, shirt tails in).

managers and employees to gain different perspectives on safety issues and practices in the work area. Approximately 20 employees were interviewed as were 80% to 100% of the managers and supervisors.

At the start of the assessment, hourly employees from the power thermal area nominated their peers to be part of a design team. This was a voluntary team that would help design and implement the process. The team consisted of 10 hourly employees, an area manager and a committee leader who was also an hourly employee.

Stage 2: Process Design & Executive Overview

The design team worked with the consultants to design the process for each unit of the power thermal area. Planning sessions were held biweekly for 3 weeks. At the end of the design stage, the team presented an overview of its plans to managers and supervisors for feedback and endorsement.

The executive overview was critical for obtaining buy-in from upper management and supervisors. The purpose was to make sure managers and supervisors knew about and approved the proposed changes. The objectives of this overview were to: 1) provide an overview of the elements of the behavioral safety process and why it was being implemented; 2) ensure that line management knew how to support the implementation; and 3) let people know how to influence the process. Overall, the overview outlined the plans of the design team for the managers and supervisors so they knew what to expect through the different stages of the process (McSween, 2003).

Stage 3: Safety Observation Training

The design team assisted in delivering safety training to all employees—from the managerial level down. Training on the rationale and the steps for conducting safety observations was delivered in 8-hour blocks to employees in groups of 20. In addition, employees practiced conducting observations with video models depicting scenarios in their work areas. Practice video observations were a required portion of the training. Participation as a safety observer was strictly voluntary for hourly employees but mandatory for supervisors. All employees were told they might be observed by other workers and observers announced the observation before proceeding; thus, employees were aware they were being observed while they worked.

Stage 4: Safety Observation & Measurement

The design team tracked three primary measures: 1) the number of observations conducted; 2) the percentage of observation participation; and 3) the types of safety concerns raised by observers. Observers were asked to complete at least two observations per month. Observations were conducted using checklists that defined critical safety practices. During an observation, employees evaluated peer performance based on the safety definitions provided on the checklist. Table 1 provides an example of safety practices included on the checklists.

Stage 5: Feedback, Recognition & Celebration

Employees received monthly feedback on the number of observations conducted, participation rates (defined as the percentage of employees completing at least two observations per month), and the number and types of safety concerns raised. Verbal feedback was delivered by design team members during monthly safety meetings, and most units posted graphs of the data along with lists of employee suggestions and actions taken to remedy safety issues. The data were tracked locally by the area safety teams and used as the basis for action plans.

Employees celebrated increasing participation rates with team meals and award ceremonies, which managers attended consistently. During the celebrations, unit data were presented and employees were recognized as safety champions for their participation in the process. Safety champions were nominated by peers for their safety suggestions, near-hit

Abstract: *This article describes the implementation of a behavioral safety process in a CITGO Petroleum Corp. oil refinery. Data presented show the long-term effects of the implementation on recordable incident rates, lost-workday case rates and direct costs of injuries. The implementation contributed to decreases in recordable injuries, lost workday cases and workers' compensation costs, and promoted desired changes in the organization's safety culture.*

reporting, hazard reporting, and overall leadership and support of the process.

Plant-Wide Implementation & Maintenance

Following the pilot implementation, the safety process was implemented in the five remaining work areas. This presented numerous challenges, but the refinery was able to successfully maintain the system. The refinery's three primary safety committees work together to promote safety: the site-wide safety awareness committee conducts awareness campaigns; the union management SH&E committee addresses workplace hazards; and committees in each area promote safe work practices and identify hazards.

Each work area dedicates bulletin boards on which it posts graphs or lists of the number of observations conducted, percentage of observation participation, safety concerns, campaign or contest announcements, and safety team meeting minutes. A safety newsletter is distributed, and a website devoted to the plant's safety progress was created as well. Plant management allocates funds to support the continued improvement (e.g., recognitions, celebrations) of the safety process.

Although the activities and support described cannot be directly linked to the maintenance of the safety process and reductions in injuries over time, it is likely that each contributed to promoting the importance of safety throughout the plant. In addition, increasing employee participation in the safety observations demonstrates how the process has been sustained over time.

Results & Discussion

Observations & Incident Data

Figure 1 shows the relation between the number of safety observations conducted and the occurrence of incidents for the power thermal area. In the 14 months that preceded safety observations, one or more incidents occurred per month. After observations began in August 1994, no incidents occurred for 8 out of 11 months. Figure 2 shows the number of recordable injuries for the power thermal area before and after implementation. The single recordable injury in 1994 occurred during the first quarter of the year, before the safety intervention, and no recordable injuries occurred in the area in 1995. The area went 24 months without a recordable injury for the first time.

Figure 3 shows more recent employee involvement in the observation process. Plant-wide employee participation in the safety observation process has continued to rise. In 2000, 63% of employees at the plant were conducting safety observations; in 2007 (using data available at the time the time of writing), 93% of employees were participating.

Figure 4 shows the refinery's lost-workday cases from 1987 to 2003. Although the cases were declining before implementation, a substantial decrease in variability occurred after the process started. Data for the pilot area indicate that the area had no lost-workday cases 4 years after implementation. These data suggest that the safety

Figure 1

Safety Observations & Incidents

Relationship between the number of safety observations and the number of incidents in the power thermal area, June 1993 to June 1995.

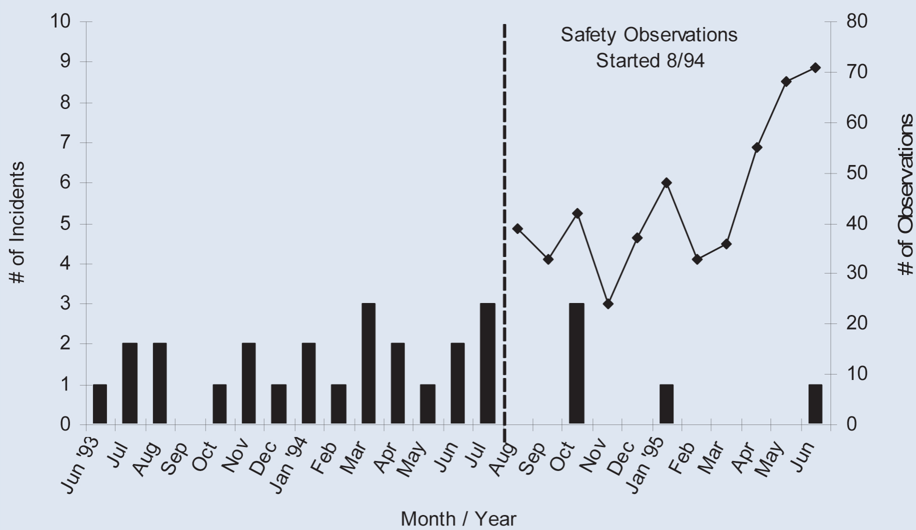
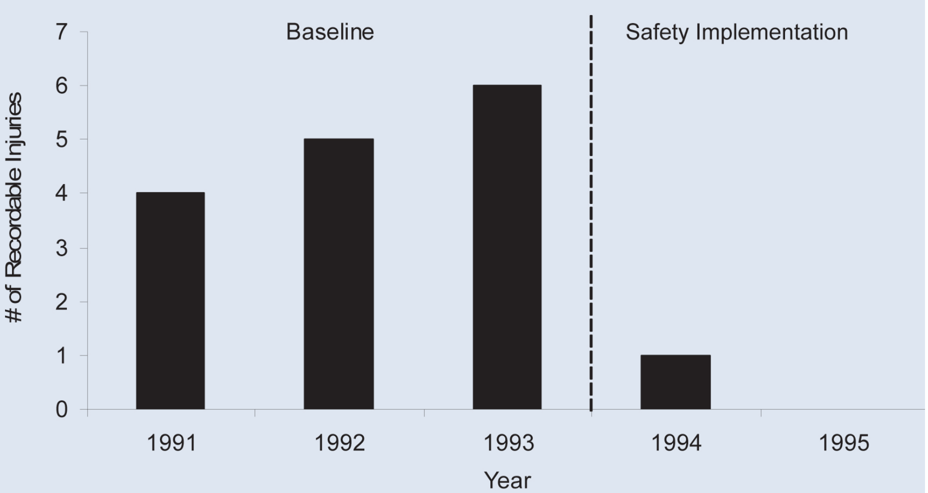


Figure 2

Recordable Injuries

Recordable injuries for the power thermal area, 1991 to 1995.



process helped the refinery achieve and maintain a low rate of lost-workday cases.

Figure 5 (p. 40) shows the refinery's 12-month moving recordable incident rate. The data show a steady decrease in recordable injuries from 2000 to 2007. In addition, from July 2002 through April 2005, 7.3 million workhours were recorded without a lost-time case; from May 2005 through September 2006, 4.0 million workhours were recorded without a lost-time case. From October 2006 to February 2007 (the latest data available), 1.0 million workhours were recorded without an OSHA recordable incident. The continued reduction in recordable incidents is likely related to the ongoing employee participation in safety observations and the plant-wide support and participation (e.g., allocated funds, safety committee activities, graphed feedback) in the safety process as a whole, although no causal inferences can be made.

Direct Costs

Figure 6 (p. 40) shows the refinery's workers' compensation claim frequency from 2000 to 2007. Claim frequency reduced substantially from 2000 (n = 43) to 2001 (n = 21), and continued to trend downward in later years. Figure 6 also shows the refinery's paid workers' compensation costs from 2000 to 2007 (using data available at the time of writing). Paid costs were approximately $1.05 million in 2000, but continued to remain below $1 million in subsequent years.

Conclusion

According to Randy Carbo, vice president of the Lake Charles refinery, the behavioral safety process has not only thrived and been maintained, it has also become part of the site's culture. He stresses the critical role of leadership and explains that area managers meet regularly with the safety committees, which have a direct link to upper management through the safety awareness committees. In addition, the vice president meets with the CEO each month and safety is the first item of discussion. The positive effect of the Lake Charles safety process has also recognized by external entities. For example, the vice president reported that contractors often recognize CITGO's dedication to safety. Following the implementation in the first plant, CITGO implemented the safety

Figure 3

Plant-Wide Employee Participation

Plant-wide employee participation in the safety observation process, 2000 to 2007.

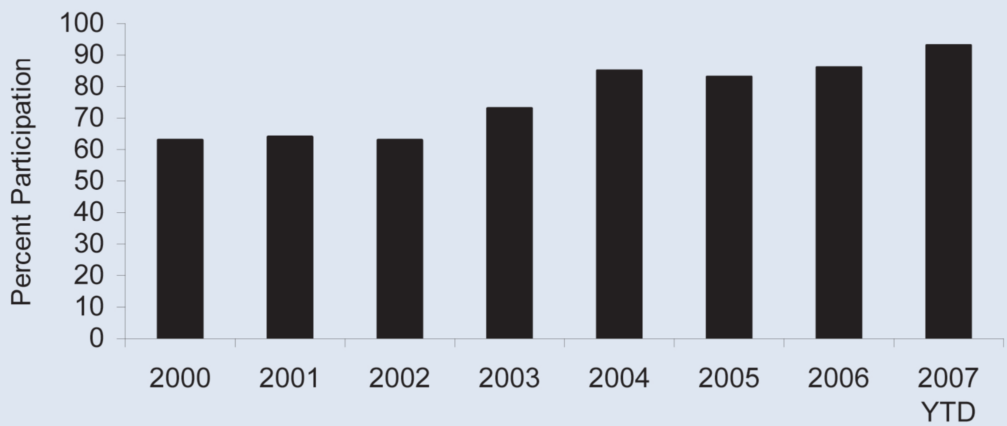


Figure 4

Lost-Time Incident Rates

Plant-wide lost-time incident rates before and after safety implementation, 1987 to 2003.

Figure 5

12-Month Moving Incident Rate

Plant-wide 12-month moving OSHA incident rate, 2000 to 2007 (using latest available data).

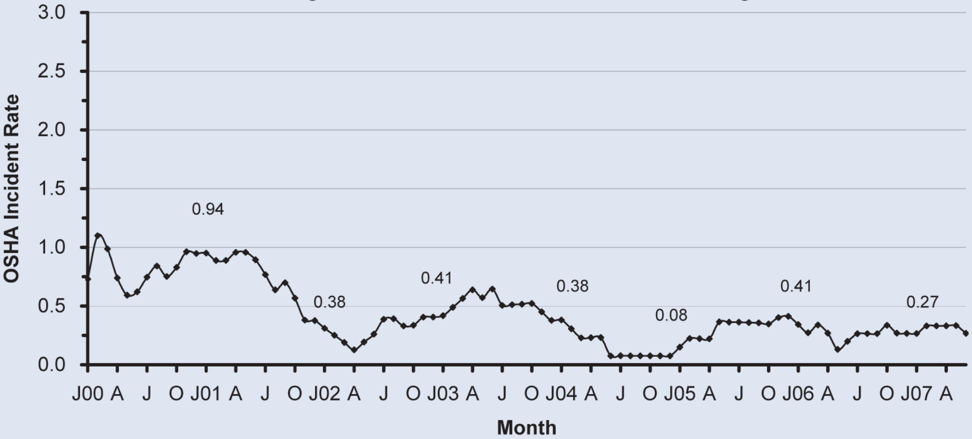
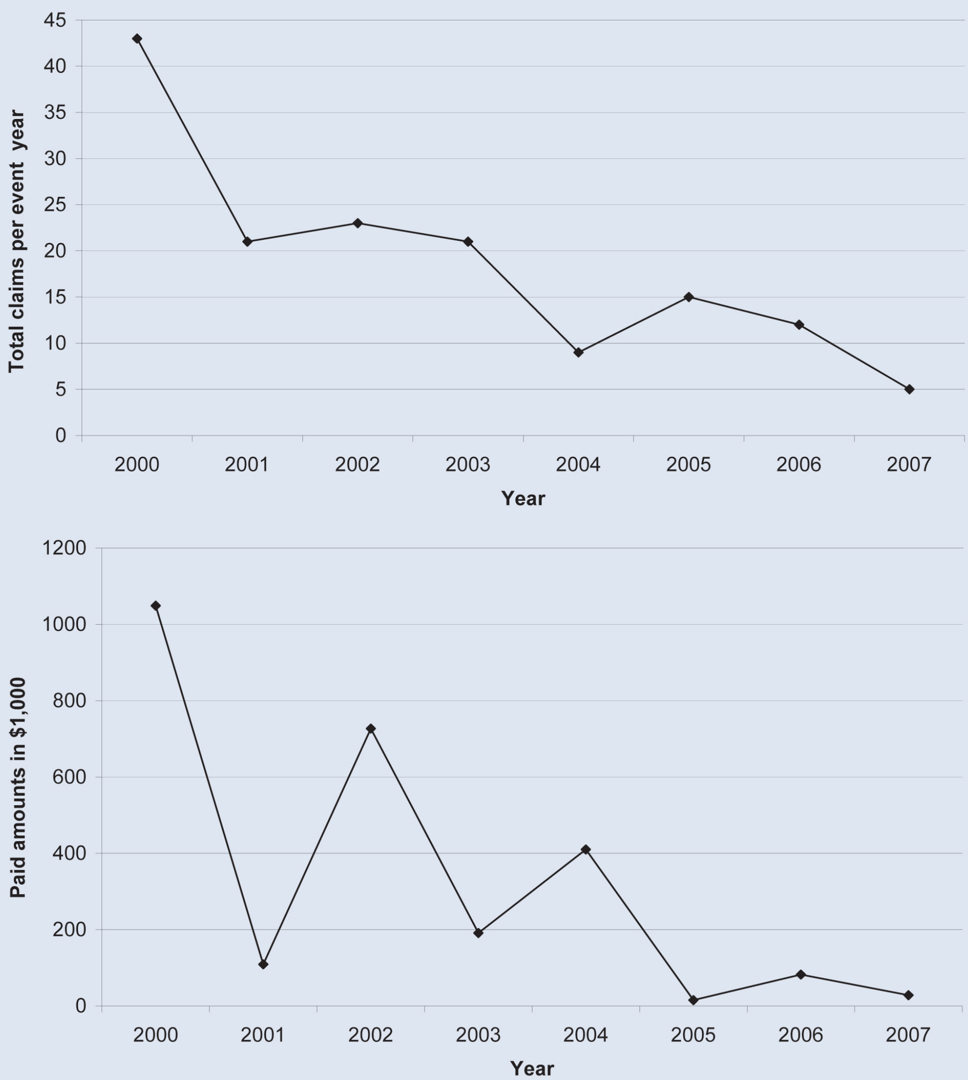


Figure 6

Workers' Compensation Claim Frequency & Paid Cost

Plant-wide workers' compensation claim frequency and paid workers' compensation cost per event year (includes only actual amounts paid).



process in a second refinery and the company recently identified behavioral safety as a best practice for the organization, which provides further support for the success of the process.

Petroleum refineries present many challenges to the implementation and maintenance of a unified safety system. Refineries are expansive facilities with self-contained work areas and large workforces that operate at high capacity, around the clock. Such environments create serious financial and health risks for companies in the face of major incidents.

The safety system discussed here was successfully implemented and has been maintained over a 20-year period. This implementation demonstrates the effectiveness of a behavioral safety process as a program component in complex work environments. ■

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