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A survey-based system for safety measurement and improvement

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Abstract

Problem: A task force sought to develop a method for safety measurement that is reliable and valid and provides a framework for improvement efforts. *Method*: Over a 10-year period, through working in a chemical company with about 6,000 employees and over 50 plants, the authors researched the use of employee surveys to measure safety and as a diagnostic tool for improvement efforts. *Results*: The statistical studies indicate that this survey, which evolved from the Minnesota Safety Perception Survey, is both reliable and valid as a measurement tool. The survey measures important components of the management system including (a) management's demonstration of commitment to safety, (b) education and knowledge of the workforce, (c) effectiveness of the supervisory process, and (d) employee involvement and commitment. This study also describes anecdotal evidence that the diagnostic element of the survey enables the development of effective action plans to improve safety performance. This evidence includes ratings of the process by plant managers who have used it. *Impact on industry*: The survey and related methods have helped to improve safety performance in several companies.

Keywords: Survey; Measurement; Management; Diagnostic; Improvement

1. Introduction

Beginning in the early 1980s the concepts taught by Dr. W. Edwards Deming (1982) began to change American management methods. Deming applied scientific methods to business processes. He stressed the importance of what he called "profound knowledge," the knowledge of *variation*, *psychology*, the *theory of knowledge*, and the *theory of systems*. He applied this knowledge through a cycle of plan–do–check–act, often called the PDCA cycle, which Deming attributed to his mentor Walter Shewhart.

In the plan phase the objective is to study the system. Based on the findings, the do phase is initiated. This represents action to improve the system, taken on a limited scale. The effects of the action are checked, and if the action is effective, a large-scale action is initiated. The cycle then begins again. These methods have worldwide acceptance in manufacturing.

2. Safety and quality are one and the same

Since 1989, researchers have been engaged in the application of Deming's principles to the problem of improving safety performance (Carder, 1994; Ragan & Carder, 1994).

All businesses produce something: a product, a service, or both. They also produce accidents. They usually produce them reliably. It is not possible to predict exactly *when* they will happen, but it is likely that you can predict how many will happen over a certain period, within statistical limits (Deming, 1993).

Accidents in and of themselves are evidence that the business does not have perfect control of the process that they are operating. Accidents are an important source of information about defects in business processes. It is unlikely that a unit with an unusually high frequency of accidents will be maximally effective in either productivity or quality. Deming (1993) discusses fires at a particular plant. In his example, he demonstrates that they follow a Poisson distribution, and thus can be assumed to result from "common causes." Therefore, only a change in the management system will reduce their frequency. The term

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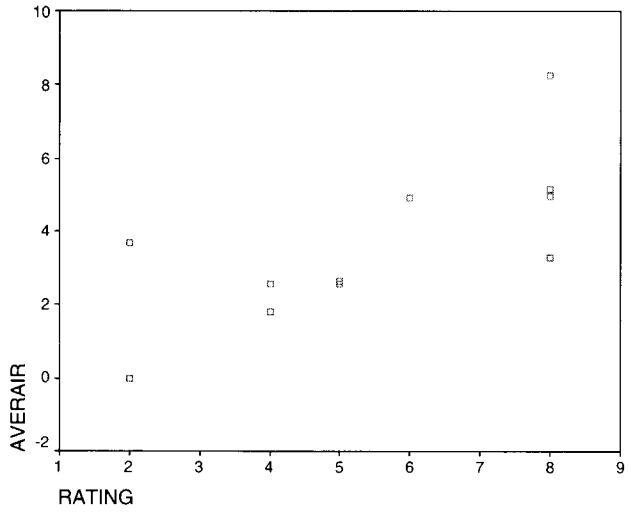

Fig. 1. Scatter plot of manufacturing rating (RATING) against recordable accident incidence rate (AVERAIR).

"accident" implies a "special cause." In most cases, plotting accidents on a control chart reveals a stable process, indicating that these accidents result from common causes.

The concept that safety and quality are both indications of the effectiveness of the management system is supported by a study conducted on 12 plants within a large chemical company. Six were selected because they had low accident rates and were judged by safety professionals to have good safety programs. Six were chosen because they had higher incident rates and were judged by safety professionals to have safety programs in need of improvement.

A staff group within the manufacturing organization had studied these 12 plants in the previous year (along with all the company's other plants) to determine the effectiveness of each plant's management system in producing quality and productivity. The scatter plot in Fig. 1 demonstrates the correlation between the rating (RATING) and the recordable accident incidence rate averaged over the prior 3 years (AVERAIR). Plants with weak manufacturing management systems had higher accident rates. The Pearson correlation coefficient is .73, which is statistically significant beyond the .005 level.

3. Application of TQM principles to safety

In 1992, the authors began a project to assist a large chemical company in the implementation of a safety process based on Deming's principles. The second author was the corporate safety director and the lead author was a consultant. The first task was to introduce a measurement system to accomplish the planning phase of the PDCA cycle. Most companies use at least two measures in their evaluation of the safety system: (a) accident/incident rates and (b) audits. Incident rates are important, but they are not always useful for process improvement. Without excellent investigation of causes, incident rates tell us that there is a problem, but they do not tell us what the problem is. If performance is outstanding, there are no incidents to investigate. Thus, there are no data to assist in guiding performance improvement. In addition, the criteria that qualify an event as a recordable accident are not designed to include events that cause no injury but may portend very serious future problems if not corrected.

Audits are on less firm ground. The authors are not aware of studies validating audit scores against performance. Polk (1987) surveyed 18 railroads regarding various elements of their safety programs. (Polk's finding is summarized in Bailey & Petersen, 1989.) He reports a significant *negative* correlation between the level of "reviews, audits, and inspections" and accident rates. The more reviews, audits, and inspections, the higher the accident rate. The audit process was never involved in Deming's approach to quality. By exhorting companies to "cease dependence on mass inspection," Deming (1982) was pointing out that after-the-fact inspection, unless conducted in the manner necessary to create a control chart, does not help to build understanding of the work process.

What is needed for the planning phase is a diagnostic measure of the safety management process. In 1993, the authors decided to investigate the use of standardized surveys for this purpose. Initially, the authors worked with Charles Bailey to administer a modified version of the Minnesota Safety Perception Survey (Bailey, 1997; Bailey & Petersen, 1989) to over 6,000 employees in over 50 chemical plant sites. Bailey's 74-question Minnesota survey was used, to which there were questions added that were written by involved researchers. All questions are yes/no questions.

For the initial validation studies, the 12 sites mentioned previously were used. They had been selected as pilot sites before the survey was administered. These 12 sites were judged by safety professionals to have relatively equal hazard risk, so that a lower incident rate was indicative of a more effective safety-management system. Following the administration of the survey, each question was validated using the following procedure: For each question there is a desirable answer and an undesirable one. For example, if the question is, "Is your training regularly updated?" the desirable answer is "yes." For each question, responses are put into a 2×2 table (Table 1).

If the question is "valid," the excellent sites should have a higher proportion of desirable answers. This was tested using a Yates-corrected chi-square statistic, with a requirement that the one-tailed statistical significance be at or beyond the .05 level. A one-tailed test was used because the researchers were predicting the direction of the difference.

These validation studies found that some of the original questions from the Minnesota survey were not valid in this

Table 1
2 × 2 Table for question validation

	Desirable answer	Undesirable answer
Excellent site(s)		
Site(s) in need of improvement		

test environment, even though they had been validated using a similar procedure when the Minnesota survey was developed (Bailey, personal communication). Based on the study, these questions were discarded. Although Bailey (personal communication) has reported that only the scores of hourly workers were valid, these studies showed that the scores of managers, though generally a bit higher, were valid as well using this procedure.

Over the years, questions have been added to address some issues that are important to chemical companies: emergency response, process safety, and environmental protection. These topics were not addressed by the original Minnesota survey. These have been validated as well using this procedure.

The survey is administered to all employees at the plant site, although the usual response rate is 80–90%. Usually this is done at safety meetings. The surveys are passed out by either a manager or an hourly safety team member. They are handed in using a "ballot box" system and the workers are assured that their anonymity will be protected. The ballot box is shipped to the contractor for analysis. To further guarantee anonymity, no reports are generated on groupings less than five. If a department is smaller than that, it will not be broken out in any analysis.

There are frequent comments from respondents about the difficulty of yes/no questions. Respondents are told to make the best choice they can, or if they cannot answer, to leave the question blank. These scores represent the number of desirable responses on a question, divided by the total number of responses to that question. Marking both yes and no, or leaving the question blank, is scored as a nonanswer.

The current Health Safety and Environment (HSE) survey retains 41 questions from the original Minnesota survey and 55 questions developed by this team. The questions are listed in Appendix A. All of these questions have been validated in more than one study. The authors are not aware of any other studies on the validity of these questions since the Minnesota survey was created.

The next phase of this study was to better understand what was being measured by the survey. The original Minnesota survey purported to measure "20 factors influencing safety performance." As far as can be ascertained, this was based on the opinion of the survey's authors, who were all experienced safety professionals. Initially, researchers attempted to verify these 20 components by measuring the correlations between questions. It was found that questions within 1 of the 20 components often correlated more strongly with questions in other components than with questions in their own component. This failure to confirm the 20 factors led the authors to conduct a principal components factor analysis of the database.

The factor analysis indicated that the original Minnesota survey measured six factors. Rather than name the factors immediately, focus group research was conducted with survey respondents to better understand the factors. The groups were made up of managers and hourly workers in the plant sites that had been surveyed. The focus group participants were shown a set of questions that represented a single factor, and then they were asked to determine what variable they felt was being measured by those questions. Each factor was considered by at least two groups in sessions lasting about 3 h.

Based on the focus group discussions the factors are named as follows:

- Management's *demonstration* of commitment to safety. Do management's *actions* convey the message that safety is very important.
- Education and knowledge of the workforce. Are workers properly trained to do their jobs, and do they receive proper safety training? Do they understand their jobs and how to work safely?
- Effectiveness of the supervisory process. Does the company have standards for work, and are these standards enforced?
- Employee involvement and *commitment*. Are employees involved in the planning process, and are they sufficiently committed to caution coworkers about unsafe practices?
- Drugs and alcohol (fitness for duty). Is drug and alcohol use prevalent and tolerated?
- Off-the-job safety. Does the company have an effective off-the-job safety program?[1]

The additional factors created by these new questions include emergency preparedness, process safety, and environmental protection. Appendix A includes the factor represented by each question.

The first four factors appear to be relatively universal, being similar to the results of other attempts to identify the critical components of the management system. Table 2 depicts these factors along with the factors derived from three other sources: (a) the factor analysis of a database from the application of a safety perception survey entitled the "Safety Barometer" developed by the National Safety Council (NSC, 2003); (b) a factor analysis conducted by Coyle, Sleeman, and Adams (1995) on a safety survey that

[1] Our focus group research found that employees consider this to be very important. It conveys the message that safety is not just an economic issue for management.

Table 2
Management system factors

Our survey	Safety barometer	Coyle survey	Dow self-assessment
Management's demonstration of commitment	Management's demonstration of commitment	Maintenance and management issues	Line management leadership
Education and knowledge	Not present	Training and management attitudes	Training
Quality of supervisory process	Quality of supervisory process	Accountability	Operating discipline
Employee involvement and commitment	Employee involvement and commitment	Personal authority	Total employee involvement
Off-the-job safety	Not present	Not present	Off-the-job safety
Emergency preparedness	Not present	Included in company policy	Not present
Drugs and alcohol	Not present	Not present	Not present

they developed; and (c) the factors identified by a group of managers at Dow Chemical in the 1980s that formed the basis for the company's "self-assessment process."

The first four factors are present in all of the surveys except for the NSC safety barometer, where no education and knowledge component was found.

In a similar vein, the Occupational Safety and Health Administration (OSHA), through their VPP Star program, has identified "four major elements of an effective safety program" (OSHA, 1989). These are (a) management commitment and employee involvement, (b) work site analysis, (c) hazard prevention and control, and (d) safety and health training. These elements overlap. According to OSHA, hazard prevention and control must include a "clearly communicated disciplinary system." This is similar to the studies' factor, quality of the supervisory process. Taking this into account, the OSHA elements cover all of the elements from this study.

4. Reliability and validity of this safety survey

The reliability of the survey instrument (i.e., its ability to yield consistent results for repeated administrations) was established in two ways. The researchers used the split-half technique where a person's responses to one half of the survey's items (randomly selected) were correlated against their responses to the other half. Results here found reliability coefficients in the range of .9, indicating a high degree of reliability.

The second procedure took account of the fact that the survey had been administered to many plants over a succession of years. Fig. 2 is a scatter plot of scores for the same plants when measured in 1996 (POS96) and 1997 (POS97) by the same survey instrument. The correlation between the two test scores (the overall percentage of desirable responses) yielded a Pearson r of .82, indicating again a relatively high degree of reliability. A perfect correlation is not desirable here. It is assumed that some sites will do more than others to implement changes based on the survey and that the scores of these sites will improve in comparison to the scores of sites that do not take significant action. In fact, based on survey questions that ask whether the site has taken action on the previous survey, it was found that this is true. There is a positive correlation between the proportion of desirable answers to this question and the change in the survey score of the site. In one study of 23 sites for which there were data from 1996 and 1997, the Pearson r correlation between the questions on response to the survey and the change in the site's overall score from 1996 to 1997 was .51 ($P < .012$).

Evidence of the validity of the survey instrument (i.e., the extent to which it actually measures what it is intended to measure) was also determined through multiple procedures. One was to correlate survey scores for plants against their recordable accident rates. Given two sites with relatively equal hazard risks, the one with the better survey score should have fewer accidents. An initial validation study used the 12 sites mentioned above. The survey score (HOURLY—indicating the scores of hourly workers), meaning the overall proportion of desirable answers was

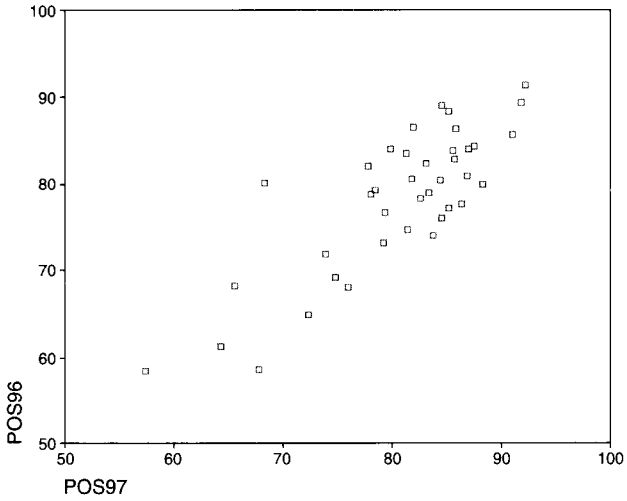

Fig. 2. Scatter plot of 1997 survey scores against 1996 scores for 39 sites.

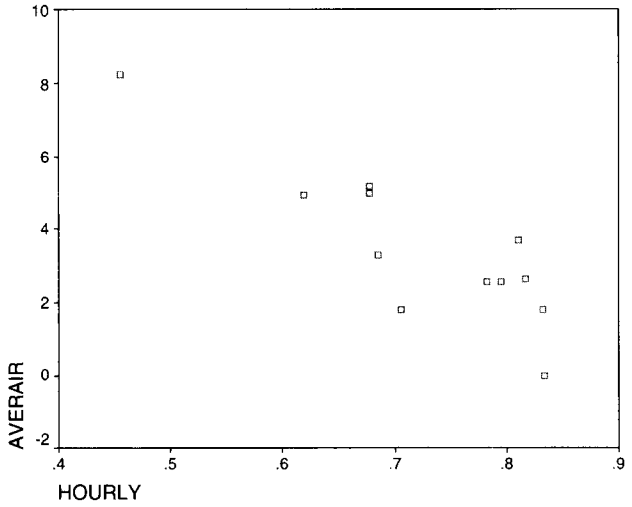

Fig. 3. Scatter plot of survey scores against AVERAIR for 12 sites.

correlated against the recordable accident rate (AVERAIR) averaged over 3 years before the survey. Fig. 3 is a scatter plot of this relationship, which shows that sites with higher (better) survey scores tend to have lower accident rates. Reflecting the inverse nature of the relationship, the Pearson coefficient in this case is −.87, and is significant beyond the .0005 level.

In addition to validating the overall survey score, each individual question on the survey was validated in at least two studies using the methods described above with the chi-square statistic. As noted earlier, some of the questions in the original Minnesota survey did not validate in these studies. In fact, the authors tested their validity in the chemical industry and in a company that manufactured copy equipment. Ten questions were found that did not validate in either setting. There are two obvious hypotheses about why this might be: (a) The Minnesota survey validation studies were done around 1980, and times have changed. One of the questions that failed to validate asked whether "drug or alcohol use increases incident rates." In 1980, some individuals might have said "no." Now virtually all respondents answer yes, making it impossible to differentiate between weak programs and excellent programs. (b) The Minnesota survey studies were conducted at railroads. It may be that manufacturing operations are different.

A third method for establishing validity has been to ascertain whether the survey data offer insights into areas in need of improvement, and whether interventions targeting these weaknesses do in fact result in positive changes in safety performance.

In the authors' experience, units that administer the survey and follow it up with employee focus groups and implementation of action plans experience a significant reduction in their recordable accident rate. The process that is recommended for developing targeted actions based on the survey data is as follows:

1. Survey results are fed back to the employees who took the survey.
2. Employee focus groups are convened to further understand the results and assist in developing focused action plans.
3. Senior management reviews the action plans.
4. Actions are implemented with clear support from senior management.
5. Results are measured, using performance measures and the survey. (The authors recommend repeating the survey every 1 to 2 years.)

Fig. 4 shows a control chart of recordable accidents before and after the application of the survey process for a company that administered the survey and engaged in the process detailed above. The control chart, a U-chart (Duncan, 1986), demonstrates a reduction in the recordable rate that is statistically significant. The boxes

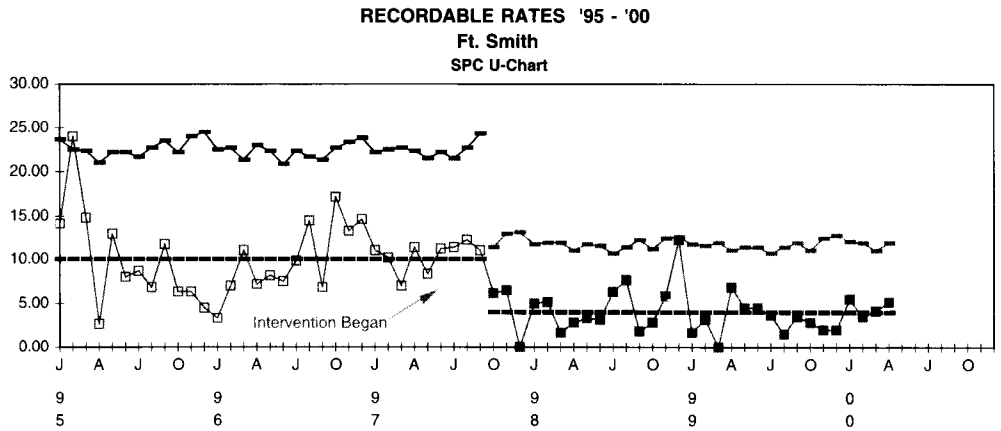

Fig. 4. Control chart of recordable accidents before and after the survey-based improvement process.

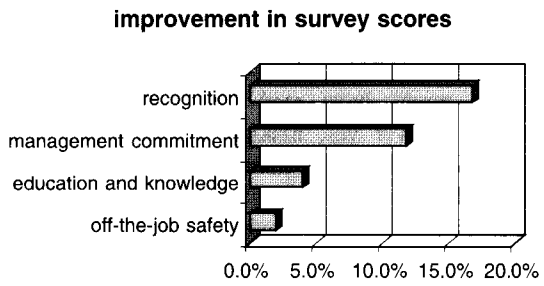

Fig. 5. Changes in four survey components as a result of survey-based intervention.

represent the recordable rate for each month. The upper line represents an upper control limit, and the dotted line represents the mean. Starting in October of 1997, about 3 months after the administration of the survey, there is a run of 14 points below the mean. A run of 7 points is sufficient to justify the assumption that the process mean has changed (Duncan, 1986). Therefore, a new mean is computed and extended back to October. The filled boxes are the recordable rates following the process shift.

The authors' experience indicates that organizations that go through the process outlined above typically experience a reduction on the RAIR in the range of 25–50%. Other workers have reported similar results. O'Toole (2002), working with a chemical company, used a portion of this survey to develop an action plan. Following the implementation of the plan, he observed a reduction in lost time rates of more than 50%.

The problem with using such studies to demonstrate the efficacy of the process is that it is difficult to assert experimental control. An obvious method would be to take a large company and randomly assign some of the plant sites to a survey-based improvement program and others to different interventions. This is unlikely to be achieved in practice. There are two additional sources of data, however, that reinforce the assertion that this survey-based process is an effective diagnostic tool in designing actions to improve safety performance:

1. The results of improvement efforts are specific to the survey diagnosis, not general. A limited version of the survey at a pipeline company was conducted. The finding was that management commitment to safety was perceived as weak, and that recognition of employees for their contributions to safety, a component of management commitment, was lacking. Based on this finding the company implemented a recognition program and increased management's visibility in supporting safety. Eight months later their employees are resurveyed. The changes in survey scores are reflected in Fig. 5.

The improvements in recognition and management commitment are statistically significant, the other two changes are not. These improvements are specific to the areas targeted by this intervention. It might be argued that this is simply regression to the mean. These scores are the lowest and therefore most likely to improve. However, working with this survey over several years, the authors observed that when a factor is low in 1 year, it will be low the next. The pattern of response across the factors measured by the survey is remarkably consistent from year to year. Moreover, the intervention was effective in improving performance. This company experienced a long-lasting reduction in the recordable accident rate in excess of 50%.

2. Plant staff view the survey as a useful tool. While there is considerable circumstantial evidence that the survey process is useful in improving safety performance, the opinions of operational management are relevant in this matter. To ascertain line management's opinion of the effectiveness of the process, a population of 22 plant managers was surveyed who had used the survey annually for 3 years.

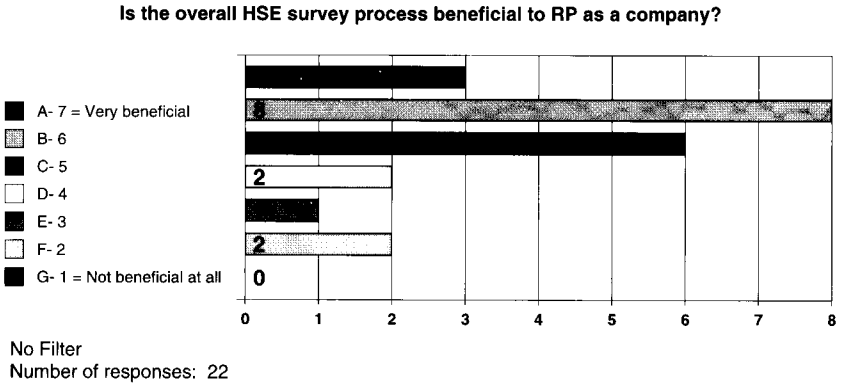

Fig. 6. Opinions of plant managers regarding survey benefit.

Fig. 6 shows their opinion on the usefulness of the survey for the company.

Most of the respondents felt the survey was useful. Verbatim comments included the following:

[The survey] allowed the site to prioritize safety programs to meet the employees concerns. For example, in the first year we reemphasized emergency response, then off site safety. In later years, we have emphasized management of change and supervisory safety processes.

[The survey] highlights latent problems of which we were unaware.

[The survey offers] identification of areas needing improvement from the employee viewpoint.

It provided a basis for developing the 1997 Safety Programs.

Some good input was gained on several significant safety issues in the follow-up discussions.

[The survey helps] to prioritize actions and empower groups to develop management systems in those areas.

[The survey] builds safety awareness. Improves safety culture. Provides input from people other than manufacturing. Identifies problem areas. Can help to improve process safety.

[The survey has employee] buy in to "Safety" from nonmanagement employees.

[The survey] helps get input so that HSE processes can be improved. Just conducting the survey and feeding back results communicates a level of commitment to HSE excellence.

[The survey is] the best measurement tool currently available.

5. Conclusions

This work suggests that this survey process provides a reliable and valid metric of the safety management system. The components of the management system that it measures appear to be fundamental components, including management's demonstration of commitment to safety, education and knowledge of the workforce, effectiveness of the supervisory process, and employee involvement and commitment. This work and that of others further indicate that the survey can be used effectively as a diagnostic tool to direct safety improvement efforts.

References

Bailey, C. W. (1997). Managerial factors related to safety program effectiveness: an update on the Minnesota perception survey. *Professional Safety, 42*, 33–35.

Bailey, C. W., & Petersen, D. (1989). Using safety surveys to assess safety system effectiveness. *Professional Safety, 2*, 22–26.

Carder, B. (1994). Quality theory and the measurement of safety systems. *Professional Safety*, 23–28.

Coyle, I. R., Sleeman, S. D., & Adams, N. (1995). Safety climate. *Journal of Safety Research, 26*, 247–254.

Deming, W. (1982). *Out of the crisis*. Cambridge, MA: IIT Center for Advanced Engineering Study.

Duncan, A. J. (1986). *Quality control and industrial statistics*. Homewood, IL: Irwin.

National Safety Council (NSC). (2003). *Safety barometer database*. Itasca, IL: Author.

Occupational Safety and Health Administration (OSHA). (1989). Safety and health program management guidelines; issuance of voluntary guidelines. *Federal Register, 54*, 3904–3916.

O'Toole, M. (2002). The relationship between employees' perceptions of safety and it's management culture. *Journal of Safety Research, 33*, 231–243.

Polk, J. F. (1987). *Statistical analysis of railroad safety performance. 1977 1982* (Final Report of Contract DTFR 53-82-X-0076). Federal Railroad Administration.

Ragan, P. T., & Carder, B. (1994). Systems theory and safety. *Professional Safety, 22*.

Appendix A. Survey questions

Factor	Question
Management demonstration	Does management insist upon proper medical attention for injured employees?
Management demonstration	Is safe work behavior recognized by supervisors?
Management demonstration	Do you believe the equipment and facilities you work with are maintained to ensure a safe operation?
Management demonstration	Do supervisors pay adequate attention to safety matters?
Management demonstration	Do employees participate in setting goals for safety?
Management demonstration	Do you think your company seeks prompt correction of problems found during inspections?
Management demonstration	Is safe work behavior recognized by your company?
Management demonstration	Have your company's efforts encouraged you to work more safely?
Management demonstration	Are maintenance programs at a level which help prevent accidents?
Management demonstration	Do different departments work together to improve the safety of processes?
Management demonstration	Are changes to procedures and processes adequately reviewed to insure safety?

(continued on next page)

Appendix A (*continued*)

Management demonstration	Do you feel the processes you work with are properly designed to operate safely?
Management demonstration	Does your supervisor ask what you need to make your job safer?
Management demonstration	**Are there barriers that prevent you from having adequate communication with other groups in the company?**
Management demonstration	Our company's HSE philosophy is well understood.
Management demonstration	Our company is doing more about HSE than most other major chemical companies.
Management demonstration	Do operators and engineers communicate effectively?
Management demonstration	I believe my company wants to be the best it can be in HSE.
Management demonstration	Adequate resources are applied to the HSE effort.
Management demonstration	Management is as concerned about safety success as it is about business success.
Management demonstration	Are contractors at your site required to meet your company's HSE standards?
Education and knowledge	When you are asked to do a new job do you receive proper training?
Education and knowledge	Are employees adequately informed about the results of their exposure monitoring?
Education and knowledge	Is amount of safety training given supervisors adequate?
Education and knowledge	Are safety rules regularly reviewed with employees?
Education and knowledge	Do the people in your department understand the relationship between what they do and the company's safety program?
Education and knowledge	Did you receive adequate safety training related to your job?
Education and knowledge	Do employees understand the hazards of the operations they perform?
Education and knowledge	Do supervisors provide a safety orientation for newly assigned employees?
Education and knowledge	Is information that is needed to operate safely made available to employees?
Education and knowledge	We share HSE information with outside groups.
Education and knowledge	Do employees understand the reasons behind the rules they are asked to follow?
Education and knowledge	Is your training regularly updated?
Supervisory process	Are minutes of safety meetings kept and follow-up files maintained?
Supervisory process	Is discipline usually assessed when safety rules are broken?
Supervisory process	Are checks made to be sure required protective equipment is being used?

Appendix A (*continued*)

Supervisory process	Do supervisors discuss safety goals and performance with employees regularly?
Supervisory process	Are employees checked on a routine basis to see whether they are doing their jobs safely?
Supervisory process	Does the company have a uniform procedure for dealing with employees who violate rules?
Employee involvement	Do supervisors discuss accidents and injuries with employees involved?
Employee involvement	Do your coworkers support the company's safety program?
Employee involvement	Do employees participate in the development of safe work practices?
Employee involvement	Do employees caution other employees about unsafe practices?
Employee involvement	Are accidents and injuries thoroughly investigated?
Employee involvement	Do employees have a regular opportunity to attend safety meetings?
Employee involvement	Do employees participate in inspections for potential hazards?
Employee involvement	My coworkers believe that taking personal responsibility for HSE is a condition of their employment.
Employee involvement	Do employees act to correct hazards they find?
Fitness for duty	Does your company deal effectively with problems caused by alcohol or drug abuse?
Fitness for duty	**Are employees who are using alcohol or drugs on the job able to work without detection?**
Emergency preparedness	Have you been trained on what to do if there is a serious emergency?
Emergency preparedness	Have you been properly trained on how to respond to emergencies in your work area?
Off-the-job	Is off the job safety a part of your company's safety program?
Off-the-job	Is your family more concerned about off the job safety as a result of the company's safety program?
Process safety	Every process and production change is fully reviewed for its potential HSE impact.
Process safety	Do you have an understanding of the chemical processes in your plant?
Process safety	Are you well trained in the chemistry of the process units you maintain or operate?
Process safety	Does your site actively search for near miss incidents?
Process safety	Are operating procedures reviewed and revised on a timely basis?
Process safety	Do people listen to your suggestions to process safety improvement and take them seriously?

Appendix A (*continued*)

Process safety	Our company is better than other major chemical companies at preventing process accidents.
Process safety	Do employees participate in process hazard reviews?
Process safety	Do you have confidence in the results of your site's process safety reviews?
Process safety	Management is as concerned about process safety as it is about business success.
Process safety	Do you receive adequate hazard analysis and process safety information?
Process safety	Do your coworkers have an understanding of the chemical processes in your plant?
Process safety	Do employees understand the hazards of operating outside normal operating conditions?
Process safety	Does your site effectively investigate incidents that have a potential for catastrophe?
Process safety	**Are changes made to processes (chemical process, procedure or personnel) without proper review?**
Process safety	Are you encouraged to suggest improvements to process safety at your site?
Environmental protection	Nothing is more important at my site than protecting people and the environment.
Environmental protection	Do you feel a responsibility to act if you see a hazard or environmental problem?
Environmental protection	Our company is committed to Responsible Care®.
Environmental protection	Do investigations often find the true causes of environmental problems?
Environmental protection	Do you believe that you personally can prevent an environmental incident?
Environmental protection	Are you trained to recognize malfunctions to prevent incidents?
Environmental protection	Environmental issues are regularly discussed.
Environmental protection	Do supervisors discuss environmental goals and performance with employees regularly?
Environmental protection	Do employees participate in the development of better environmental practices?
Environmental protection	Are environmental concerns a part of all business decisions?
Environmental protection	Our company is more committed than other chemical companies to environmental protection.
Environmental protection	Have you spoken to neighbors or friends about the Company's commitment to HSE excellence?
Environmental protection	Do supervisors discuss environmental releases and incidents with employees involved?
Environmental protection	Do employees caution other employees about practices that could lead to environmental problems?
Environmental protection	Are you encouraged to make suggestions which could prevent releases?
Environmental protection	Are you adequately trained to respond to an environmental incident?
Environmental protection	Are operations at your site designed to prevent environmental releases?
Environmental protection	Do you believe management is committed to environmental protection?
Environmental protection	Do employees have an adequate understanding of the environmental rules relating to the processes they operate?
Environmental protection	Are all environmental releases reported to management?
Environmental protection	Do supervisors pay adequate attention to environmental issues?
Environmental protection	Do employees receive recognition for doing a good job with environmental concerns?
Environmental protection	Do you have a good understanding of the particular vulnerability of the environment surrounding your site?
Environmental protection	Operations at my site are well maintained to operate free from leaks.
Environmental protection	Management is as concerned about environmental protection as it is about business success.

Questions where "no" is the desirable answer are bold-faced.

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