ABSTRACT

The March 2005 British Petroleum (BP) Texas City Refinery disaster provided a stimulus to examine the state of process safety in the U.S. refining industry. Participatory action researchers conducted a nation-wide mail-back survey of United Steelworkers local unions and collected data from 51 unionized refineries. The study examined the prevalence of highly hazardous conditions key to the Texas City disaster, refinery actions to address those conditions, emergency preparedness and response, process safety systems, and worker training. Findings indicate that the key highly hazardous conditions were pervasive and often resulted in incidents or near-misses. Respondents reported worker training was insufficient and less than a third characterized their refineries as very prepared to respond safely to a hazardous materials emergency. The authors conclude that the potential for future disasters plagues the refining industry. In response, they call for effective proactive OSHA regulation and outline ten urgent and critical actions to improve refinery process safety.

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On March 23, 2005, a fiery blast at the British Petroleum (BP) refinery in Texas City, Texas, killed 15 workers, injured 180 others, and caused major alarm in the community. According to the U.S. Chemical Safety and Hazard Investigation Board (CSB), the incident led to financial losses exceeding $1.5 billion [1]. The incident resulted in more than 300 citations for Occupational Safety and Health Administration (OSHA) violations resulting in a record fine of $21 million [2]. The magnitude of this catastrophe marks it as one of the greatest failures of process safety management in U.S. history. It was also the biggest industrial disaster since passage of OSHA’s 1992 standard on Process Safety Management of Highly Hazardous Chemicals (29 CFR 1910.119) [3].

The Texas City BP refinery blast occurred during the failed restarting of the isomerization (isom) unit that BP had shut down for repairs [4]. Isomerization is a process that uses elevated temperatures and catalysts to rearrange molecules of crude distillation products to achieve higher octane [5]. The disaster was the subject of exhaustive studies by the BP Refineries Independent Safety Review Panel [6], and the U.S. Chemical Safety and Hazard Investigation Board [1].

In January 2006, 9 months following the Texas City disaster, the Tony Mazzocchi Center for Health, Safety, and Environmental Education (TMC) and the New Perspectives Consulting Group, Inc. joined with the United Steelworkers (USW) in a study of USW-represented U.S. refineries. The USW is the bargaining agent for hourly workers at BP Texas City and a large segment of the U.S. oil refining industry. The study sought to determine the prevalence of hazardous conditions and practices resembling those connected to the 2005 BP Texas City disaster. The study also sought to examine other process safety issues, including the status of incident prevention, preparedness, and response.

This article seeks to answer two primary questions:

1. To what extent did conditions similar to those that led to the 2005 BP Texas City catastrophe exist at the nation’s other refineries; and
2. Where these hazardous conditions were present, what were refiners doing to correct them to prevent future disasters?

Carolyn Merritt of the U.S. Chemical Safety and Hazard Investigation Board (CSB) stated in 2006 that:

“The weaknesses in design, equipment, programs, and safety investment that were identified in Texas City are not unique either to that refinery or to BP. Federal regulators and the industry itself should take prompt action to make sure that similar unsafe conditions do not exist elsewhere” [7, p. 1].

A history of catastrophes has demonstrated the petrochemical industry’s weaknesses related to these long-recognized hazards. Petroleum refineries had the highest accident rates of any industry reporting as part of the Environmental Protection Agency’s (EPA) Risk Management Program (RMP) rule for both the
1999-2000 and the 2004-2005 reporting waves [8]. For the 1999-2000 reporting wave, this history was quantified in an EPA study of high-volume chemical sites that found that refineries accounted for 10% of all chemical-related accidents with nearly twice as many accidents as any other industry [9].

LIMITED EFFECTIVENESS OF PROCESS SAFETY GUIDELINES AND REGULATIONS

Major disasters at high-hazard chemical facilities have demonstrated the need for effective systems for accident prevention, and governmental and non-governmental organizations have established a wide array of related regulations and guidelines. Key landmarks on this trail of process safety disasters include those at: BP in Flixborough, UK in 1974 [10]; Industrie Chimiche Meda Societa Azionaria in Seveso, Italy in 1976 [11]; Union Carbide in Bhopal, India in 1984 [12] and in Institute, West Virginia in 1985 [13]; and Phillips 66 in Pasadena, Texas in 1989 [14]. The resulting regulations and guidelines included OSHA’s Process Safety Management of Highly Hazardous Chemicals Standard (29 CFR 1910.119) [3] and its Hazardous Waste Operations and Emergency Response Standard (29 CFR 1910.120) [15]; the European Communities’ (EC’s) Council Directive on the Control Of Major-Accident Hazards Involving Dangerous Substances [16] and its Guidelines on a Major Accident Prevention Policy and Safety Management System [17]; the International Labour Organisation’s (ILO’s) Guidelines on Occupational Health and Safety Management Systems [18]; and the Organisation for Economic Co-operation and Development’s (OECD’s) Guiding Principles for Chemical Accident Prevention, Preparedness and Response [19] and its Guidance on Safety Performance Indicators Related to Chemical Accident Prevention, Preparedness and Response for Industry [20, 21]. However, in spite of this direction, in 2006 Rosenthal and others contended, “The less than expected decrease in accident incidence has occurred because the newly adopted regulations have not resulted in the hoped for adoption of ‘effective’ process safety management systems by industry” [22, p. 136]. The CSB report on the BP Texas City disaster contends that possible reasons for the failure of these regulations are OSHA’s overreliance on high personnel injury rates for targeting inspections and its insufficient capacities for conducting comprehensive process safety inspections [1].

LESSONS LEFT UNLEARNED

The CSB’s October 27, 2005 news release noted that if BP had applied lessons learned from previous incidents at the Texas City facility, BP could have corrected flawed systems prior to March 23, 2005, possibly preventing the disaster [23]. In commenting more broadly on the concept of “lessons learned” in chemical process safety, Rosenthal noted, “It is clear that implementation of
lessons already learned could have prevented the large majority of process accidents” [24, p. 12]. Marais and her co-authors state, “Safety goals often do not coincide with performance goals . . . and in fact often they conflict. In addition, while organizations often verbalize consensus about safety goals . . . , performance and decision-making often depart from these public pronouncements” [25, pp. 5-6]. Failure to learn from previous lessons and goal conflict were documented in the BP Texas City disaster [1, 6]. Andrew Hopkins, in part working from depositions released in legal proceedings following the BP Texas City disaster, elaborated on these themes while framing the disaster in the context of an organizational structure as a whole and managerial as well as technical failures [26].

Two sets of lessons critical for effective process safety have been available to U.S. refineries. One set involves lessons from the Texas City catastrophe that refiners should have learned and applied. As early as October 2005, the U.S. CSB called on industry to apply the lessons from its preliminary findings of the BP Texas City incident to achieve safer operations [23]. Using findings from the USW study, we will examine in subsequent sections how well the industry responded to the CSB’s call [27].

The other set of lessons are those that refiners should have learned and applied from incidents prior to the 2005 Texas City disaster. The review that follows emphasizes lessons from these incidents.

A long list of petrochemical facility events prior to the Texas City disaster provides lessons directly applicable to the four highly hazardous conditions (HHCs) that were identified as key factors in the disaster and are a focus of this study. They are:

1. the use of atmospheric vents on process units (the specific type of venting system at BP Texas City was a blow-down drum with an atmospheric vent) [23];
2. siting of trailers or other unprotected buildings near process facilities [28];
3. allowing non-essential personnel in vulnerable areas during start-ups and shutdowns; and
4. failed management of instrumentation and alarm systems.

Among those that involved the release of flammable process materials to the atmosphere are the 1989 Phillips 66 explosion [14], the 1997 Shell Deer Park, Texas, refinery disaster [29], and the 2000 BP Grangemouth, Scotland incidents [30]. The 1997 explosion and fire at the Tosco Avon Refinery, Martinez, California, [31], the 1998 disaster at the Equilon refinery in Anacortes, Washington [32], and a 2000 incident at BP Grangemouth [30] 28 provided examples of failed management of instrumentation and alarms. The U.S. Department of Labor (DOL) report on the Phillips 66 disaster [14] addressed the siting of occupied buildings similar to those where workers perished in Texas City. In addition, providing lessons on siting issues were the disasters at the 1995
Pennzoil Rouseville, Pennsylvania, Refinery [33] and the 1997 Tosco Avon Refinery that documented the following:

Some of the injured were inside or near contractor trailers close to the Hydrocracker Unit. The blast from the explosion blew out the windows of one trailer and the flames prevented workers from exiting the trailer door. The workers climbed out of the trailer window facing away from the fire . . . [31, p. 22].

Finally, the descriptions of the lessons learned related to the disasters at Phillips 66 [14], Pennzoil [33], and Tosco [31] bear witness to the importance of limiting access to non-essential personnel to highly hazardous areas.

Another significant industry weakness that surfaced in this study is the extensive reliance on contract workers. The John Gray Institute study commissioned by OSHA following the Phillips 66 disaster described ways in which greater use of contract rather than direct-hire workers potentially weakens process safety [34]. That study highlighted disparities between direct-hire and contractor employees in education, language barriers, training, unionization, and the ability to participate in safety committees and discussions. Further, Rebitzer argued that existing liability rules in the host-contractor relationship potentially distort incentives for safety training and safety supervision for contract workers at petrochemical facilities [35].

In summary, widely disseminated reports and recommendations that followed the above referenced petrochemical industry incidents should have provided valuable lessons on ways to prevent the types of systems failures that contributed to the Texas City disaster. The remainder of this paper examines the extent to which refineries represented by USW applied existing guidelines and lessons leading up to and after the Texas City catastrophe.

PARTICIPATORY RESEARCH METHODS

In January 2006, we conducted a process safety survey at U.S. refineries where the USW represents workers. The study used a participatory research (PAR) methodology [36-38] involving: USW workers primarily employed at oil refineries; staff from the USW Health, Safety and Environment Department and the Tony Mazzocchi Center; USW International Union leadership; and consultants from New Perspectives Consulting Group, Inc. and the Labor Institute. Collectively, the nine current or former oil refinery workers on the PAR team represented more than 200 years of refinery experience, with much of that focused on refinery health and safety issues.

Researchers sent the mail-back survey (one survey per site) to the local union leadership at each of 71 USW-represented U.S. oil refineries (NAICS 32411). Survey instructions requested that persons from the local union knowledgeable about refinery health and safety complete the survey. The survey response
rate was 72% (51 of 71 sites). The refinery site was the unit of analysis. Consequently, in the survey we did not collect any personal identifiers or other personal information.

The completed surveys represented both industry giants and independent refineries run by 22 companies in 19 U.S. states and one U.S. territory. Collectively, respondent sites represented 34% of the 149 U.S. oil refineries and 49% of U.S. refining capacity [39]. The size of the workforce at the responding refineries ranged from fewer than 100 employees (4% of sites) to greater than 1,000 employees (18% of sites). The majority were mid-sized (52% with 100-499 employees and 26% with 500-999).

The survey asked about:

1. the prevalence of four targeted highly hazardous conditions and company actions to correct them;
2. emergency preparedness and response;
3. training;
4. contract and company workers’ preparedness to help prevent incidents; and
5. ratings of process safety systems.

It should be noted that the fourth highly hazardous condition—failed management of instrumentation and alarm systems—is addressed in a more limited manner than the other three conditions.

Central to the survey were four issues related to BP Texas City refinery investigations. In our survey, we refer to these as highly hazardous conditions as discussed earlier.

RESULTS

Pervasiveness of Targeted Highly Hazardous Conditions

This survey explored the highly hazardous conditions key to the March 2005 BP Texas City catastrophe:

1. use of process vents that release materials directly to the atmosphere
2. siting of trailers and other unprotected buildings near process facilities; and
3. the practice of allowing non-essential personnel in vulnerable areas during process start-up and shutdown.

In a more limited way, the survey also explored a fourth highly hazardous condition—failed management of instrumentation and alarm systems. The following sub-section focuses primarily on the first three of the highly hazardous conditions. Data about instrumentation and alarm systems are included in subsequent sub-sections.
Ninety percent of sites reported one or more of the three highly hazardous conditions (46 of 51 sites)—12% of sites had one of the three highly hazardous conditions, 35% had two, and 43% had all three. Two-thirds of sites (66%) had atmospheric vents on process units at the time of the survey (33 of 50 sites). Forty-two percent of these 33 sites had more than 10 of these vents and 27% (9 sites) had more than 30. The reported vents were on a wide range of process units, including five sites (16%) that used an open-ended question to report the use of blow-down drums or stacks, a key failed component in the 2005 BP Texas City catastrophe.

In the last 3 years, 78% had placed trailers or other unprotected buildings in hazardous areas (40 of 51 sites). Eleven percent of these 40 sites reported 51 or more such units (8 sites) were present.

Seventy percent reported non-essential personnel present in vulnerable areas during start-ups and shutdowns in the past 3 years (35 of 50 sites).

**Reported Incidents or Near Misses**

For those sites where respondents affirmed the presence of HHCs, the survey asked whether there had been any incidents or near misses in the last 3 years related to these conditions. The survey also asked all respondents this question related to instrumentation and alarm systems. Sixty-one percent (31 of 51 sites) reported one or more incidents or near misses involving at least one of these four conditions. Ten percent of sites reported experiencing one or more incidents or near misses involving all four highly hazardous conditions.

One site reported, “Reformate level in [the] tower was at high levels during start-up. Operations management intentionally raised levels, which did not allow operations personnel to know where the levels were. This caused a release of reformate into other areas of [the] refinery. Non-essential personnel were in areas exposed to hazards. . . .” Another wrote, “[We] always have near misses with instrumentation. [We] had a boiler failure with hydrogen sulfide release to atmosphere with contractor working in process unit next to release. No injuries.”

The following examples involved trailers and non-essential personnel in vulnerable areas: “Trailers for TA [turn-around] set-up before units are shutdown and cleared of hydrocarbons. Non-essential personnel allowed all over the unit while the unit is being shut down and started-up.” Another respondent reported an example strikingly similar to the Texas City disaster, “[During] cat[alytic] cracker start-up we had their blow-down tower over-run. Caused a vapor cloud, [but there was] no ignition source.”

**Company Actions and Their Effectiveness**

The survey asked about company actions to address the four highly hazardous conditions following the March 2005 BP Texas City catastrophe. The actions respondents reported ranged from audits to actual changes in conditions.
of company action included: 32% acted to replace atmospheric vents on process units with safer systems (10 of 31 sites); 52% acted to improve instrumentation and alarms (24 of 46 sites); 88% moved trailers or other unprotected buildings (35 of 40 sites); and 46% acted to have non-essential personnel at a safe distance during start-ups or shutdowns (15 of 33 sites).

The respondents who reported companies’ actions to address the highly hazardous conditions were asked to rate the effectiveness of these actions. To present a more complete picture of company action and inaction, researchers combined data from two different groups of questions. They included the data regarding company actions to address the highly hazardous conditions (yes, no, don’t know), and the data on the level of effectiveness of those actions (very effective action, somewhat effective action, somewhat ineffective action, very ineffective action). We report the following data assuming that the four highly hazardous conditions require very effective action. In summary, a range of 59% to 79% of respondents indicated that companies either took no action or less than very effective action related to the four highly hazardous conditions. (See Table 1.)

Training on Highly Hazardous Conditions

The survey asked respondents about the percentage of the work force the company had trained about the four highly hazardous conditions since the March 2005 BP explosion. A range of 30% to 42% of sites reported no training of the work force on these subjects following the BP Texas City disaster. Nearly as many sites reported don’t know about training on these subjects, with a range of 21% to 42% for the four conditions. Where companies reportedly did conduct training on these four conditions, a range of 3% to 26% of sites trained more than half of the work force in these four subject areas. More than 8 in 10 reported the need for more training on atmospheric vents and non-essential personnel in hazardous areas. More than half reported the need for more training on the other two highly hazardous conditions.

Emergency Prevention, Preparedness, and Response

Respondents were asked how well prepared their sites were to respond safely to a serious hazardous materials incident or emergency. Less than one-third (30%) reported that their sites were very prepared (58% somewhat prepared, 10% somewhat unprepared, 2% very unprepared; N = 48, 6% missing). Respondents were also asked if the company had taken action since the BP Texas City disaster to improve emergency preparedness and response. Fewer than half (46%) reported the company had taken such action (23 sites) while 38% said the company had not, and 16% reported don’t know. Respondents from the 23 sites where the company had taken action described: upgrading equipment;
Table 1. Corrective Actions Taken on Highly Hazardous Conditions and Their Effectiveness

<table>
<thead>
<tr>
<th>Highly Hazardous Condition Corrective Action (sites where condition present)</th>
<th>Action effectiveness rating</th>
<th></th>
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<tr>
<td></td>
<td>Very effective</td>
<td>Somewhat effective</td>
<td>Somewhat ineffective</td>
<td>Very ineffective</td>
<td>No action taken</td>
<td>Don’t know/ data missing</td>
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<tr>
<td>Replacing atmospheric vents (n = 33)</td>
<td>3%</td>
<td>1</td>
<td>18%</td>
<td>6</td>
<td>3%</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>58%</td>
</tr>
<tr>
<td>Improving instrumentation and alarms (n = 51)</td>
<td>12%</td>
<td>6</td>
<td>24%</td>
<td>12</td>
<td>6%</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>35%</td>
</tr>
<tr>
<td>Removing trailers or other unprotected buildings* (n = 40)</td>
<td>38%</td>
<td>15</td>
<td>33%</td>
<td>13</td>
<td>5%</td>
<td>2</td>
<td>8%</td>
<td>3</td>
<td>13%</td>
</tr>
<tr>
<td>Keeping non-essential personnel out of hazardous areas (n = 35)</td>
<td>23%</td>
<td>8</td>
<td>17%</td>
<td>6</td>
<td>0%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>46%</td>
</tr>
</tbody>
</table>

*Due to rounding, all numbers do not add to 100.
improving emergency response training for the fire brigade and/or other employees; and holding drills. Fewer than half of the 23 sites where the company had taken action rated that action as very effective (43%, \( n = 9 \)). The remaining 12 sites rated company actions as somewhat effective (57%).

**Emergency Response Training**

The survey asked respondents about which groups of workers had received emergency response training in the last 12 months. Nearly all (96%) reported that the company had provided such training to the emergency response team, hazardous materials (HAZMAT) team, or fire brigade, and that 77% of sites had provided this type of training to the general plant population. One quarter (23%; \( n = 11 \)) said they were very confident that the work force had received the training it needed to respond safely to a serious hazardous materials incident or emergency. Three-quarters stated that they were less than very confident (52%, \( n = 25 \), somewhat confident; 23%, \( n = 11 \), somewhat unconfident; and 2%, \( n = 1 \), very unconfident).

**Company and Contractor Preparedness to Help Prevent Hazardous Materials Incidents**

When describing how prepared routine maintenance and turnaround or overhaul workers were to help prevent hazardous materials incidents, notable differences emerged when comparing contract and company workers. Overall, respondents reported that company workers were much better prepared than contract workers to help prevent hazardous materials incidents. Only 6% of sites reported that contract routine maintenance workers were very prepared, and none of the sites considered contract turnaround/overhaul workers very prepared. In contrast, approximately one-third rated company maintenance workers very prepared to help prevent hazardous materials incidents.

**Process Safety Management Systems**

The survey asked respondents to rate 16 systems related to process safety for start-ups and shutdowns. They included:

1. design and engineering;
2. monitoring and measurement;
3. work organization and staffing;
4. alarm and notification systems;
5. management of change;
6. process hazard analyses (PHAs);
7. inspection and testing;
8. operating manuals and procedures;
9. relief and check valves;
10. training;
11. hazardous materials containment;
12. emergency preparedness and response;
13. emergency shutdown and isolation;
14. fire and chemical suppression;
15. on-site communications; and
16. off-site communications.

For only one of the 16 process safety systems examined—emergency preparedness and response—did more than one-third (34%) of respondents rate the system as very effective. For 10 of the 16 systems, more than three-quarters of respondents rated them less than very effective. For training, 90% rated this system as less than very effective. Other systems for which more than three-quarters of respondents rated the system for start-ups and shutdowns as less than very effective included: 88% for work organization and staffing; 86% for design and engineering of systems; 81% for managing the change of systems (MOC); 78% each for emergency shutdown and isolation systems, alarm and notification systems, and process hazard analyses (PHA); and 76% each for communication systems within the plant, monitoring and measurement systems, and systems for containing hazardous materials.

The survey also asked respondents to rate the overall management of process safety systems at their refinery. Eighty-seven percent rated them as less than very effective (13 percent, n = 6, very effective; 66 percent, n = 32, somewhat effective; 17 percent, n = 8, somewhat ineffective; 4 percent, n = 2, very ineffective; 0 percent don’t know; N = 48, 3 missing).

LIMITATIONS

Some findings of this study regarding effectiveness, preparedness, confidence in systems, and employer actions provide respondent perceptions rather than independent assessments. Further, findings from this study cannot be generalized beyond those sites that participated in the study. Respondents to this study all had union representation, and, therefore, may have had greater organizational mechanisms and resources than non-union sites with which to positively affect process safety, such as joint-labor management health and safety committees, full and part-time local union health and safety representatives, and international union health and safety staffs and programs.

DISCUSSION AND CONCLUSIONS

Potential for Future Disasters Plagues Industry

This study indicates that a major segment of the U.S. oil refining industry remains plagued by the same vulnerabilities that led to catastrophe at BP Texas
City. The vast majority of the studied refineries reported the presence of at least one of the highly hazardous conditions identified as key contributors to the Texas City disaster. A majority of these sites also reported one or more incidents or near misses involving these highly hazardous conditions during the last 3 years.

**Anemic Industry Response Since BP Texas City**

Hard lessons from the myriad of refinery incidents and near misses prior to BP Texas City have been explicitly outlined but have been too often ignored. Following each catastrophe, refinery workers, their union, and occupational health professionals hoped and expected that there would be a flurry of activity to improve process safety in areas that prompted the disaster. However, according to this study, even the most recent disaster in Texas City prompted limited response from refineries. A substantial majority of refineries with one or more of the four highly hazardous conditions reported that companies either took no action or took actions evaluated less than very effective.

In spite of these findings, there was a glimmer of hope among the widespread reports of faulty systems and insufficient action. There is evidence from some sites in this study that refineries can take very effective action on critical health and safety issues. These positive reports, though limited, provide the beginnings of benchmarks for the rest of the industry.

**Letter and Spirit of OSHA’s Process Safety Standard Unfulfilled**

The study findings demonstrate that for the refining industry, the letter and spirit of OSHA’s Process Safety Management of Highly Hazardous Chemicals standard remain unfulfilled. The heightened risks present during refinery process start-ups and shutdowns demand that these systems be highly reliable and at peak effectiveness. Pre-start-up safety reviews are an essential tool for identifying and correcting an array of potentially disastrous refinery conditions and are included in the Process Safety Management standard. Findings from this study indicate that at many sites these reviews, like other process safety systems, lack the robustness intended. Decisions made by oil companies, based in part on inadequate trade association guidelines, have led to the widespread presence of the highly hazardous conditions highlighted in this study. Left largely to voluntary self-regulation, the refining industry has shortcut process safety.

**Ineffective Work Organization and Staffing**

Virtually every safety system examined in this study is highly dependent on the presence of highly qualified employees in sufficient numbers to handle
normal, abnormal, and emergency situations. Yet, almost nine out of ten respondents rated work organization and staffing as less than very effective. Contract workers, including the 15 who died in the BP Texas City disaster, are a very substantial part of the work force at most every refinery. Although these 15 were not engaged in activities that contributed to the BP incident, lessons from previous disasters have shown that contract workers need to play important roles in prevention. Nonetheless, the preparedness of contract workers to contribute to incident prevention received the poorest ratings of any item in the survey.

**Under-Prepared for Emergencies**

There is a well recognized need for very effective emergency preparedness and response at every refinery. However, this study suggests that much of the refining industry is under-prepared. Emergency response training and frequent drills are critical to having a work force prepared and able to respond to a hazardous materials incident. The data show that refinery employees at approximately one in four refineries in this study labor in highly volatile situations without up-to-date training. Only one-quarter of respondents reported being very confident that the work force at their site had received the training it needed to respond safely to a serious hazardous materials incident or emergency.

**Proactive OSHA Regulation and Enforcement are Essential**

While petroleum refineries are a vital part of the nation’s energy infrastructure, the federal government has not yet demanded that the refining industry invest the resources necessary to safeguard the health and safety of highly vulnerable workers, nearby communities, and the environment. This oversight situation is in sharp contrast to other high-hazard industries such as aerospace, aviation, and nuclear power, which are specifically required to perform to very high standards. To reverse this direction, prompt government intervention, including new or strengthened OSHA standards and rigorous enforcement of such regulations, must be put in place. Process changes, replacement of antiquated equipment, preventative maintenance, adequate staffing, and other measures required for high reliability and excellence in process safety all require financial investment. Oil refiners, like BP, are reporting enormous, record-breaking profits [40, 41]. Yet in the face of increased earnings, the Chemical Safety Review Board recently reported that cost-cutting played a major role in undermining process safety in Texas City [1]. Too often, the vast wealth of the refinery industry is not used to prevent the kind of carnage and destruction we saw on March 23, 2005 from happening again.
URGENT AND CRITICAL ACTIONS

In order to prevent similar incidents in the future and to provide refinery workers, emergency responders, and surrounding communities and the environment with their rightful protection from harm, both OSHA and the refining industry must take immediate action. First, OSHA must strengthen its 1992 standard on Process Safety Management of Highly Hazardous Chemicals [3]. For example, facilities should be required to report to OSHA when their use of highly hazardous chemicals in large quantities meets the standards’ provisions for coverage. Further, the PSM standard should be amended to include all recommendations of the U.S. Chemical Safety and Hazard Investigation Board.

Second, the refining industry must take immediate and effective action on the nine essential steps outlined below. To be fully effective, refineries will have to work with worker representatives to develop and implement each of these measures. These critical steps will advance the pursuit of excellence in process safety management and protection of the nation’s workers, infrastructure, and security.

1. Establish a Process Safety Team at each refinery, including representatives selected by the local union, to plan, review, monitor, and audit all process safety activities, including the following listed items.

2. Address the four highly hazardous conditions associated with the March 23, 2005 BP Texas City disaster:
   a. Eliminate all atmospheric vents on process units that could release untreated explosive, flammable, or toxic materials to the atmosphere [42];
   b. Manage instrumentation and alarms such that there are no start-ups without documented, tested functioning of all process instrumentation and alarms;
   c. Create a definition of “safe siting” that when followed will ensure that refiners locate all non-permanent structures, including trailers, tents, or other modules beyond areas that could expose occupants to explosions, fires, or toxic releases [43]; and
   d. Ensure that all non-essential personnel are outside of hazardous areas, especially during start-ups, shutdowns, or other unstable operating conditions [3].

1 It should be noted that the American Petroleum Institute’s May 2008 addendum to its Pressure-relieving and Depressurization Systems standard did not call for the removal of atmospheric vents on blow-down drums like the one at the center of the BP Texas City disaster [40].
systems, that these systems can be operated safely in emergencies and that they will be adequately maintained.

3. Develop and implement policies requiring full safety reviews prior to all process start-ups and scheduled shutdowns.

4. Provide adequate staffing to ensure safe operation in all potential operating circumstances including start-ups, shutdowns, abnormal conditions, and emergencies including negotiated limits on overtime work and duty limits for safety-critical functions.

Necessary supporting actions include:

5. Provide effective, participatory worker training and drills carried out in conjunction with the union in the areas of:
   a. process safety management;
   b. emergency preparedness and response; and
   c. pre-start-up and shutdown safety reviews.

6. Ensure that all operating manuals and procedures are formalized, readily available, up-to-date, understandable, functional, and properly used for the safe operation of all processes including normal, abnormal, and emergency operating conditions.

7. Review and update management of change (MOC) procedures (including organizational, personnel, and process changes) to ensure that these procedures meet the recommendations of the U.S. Chemical Safety Board [32].

8. Revalidate all process hazard analyses (PHAs) at least every 3 years.

9. Implement an effective incident and near-miss investigation program involving workers and their union in all phases of investigation and recommendations for improvements.

Other major examinations of the BP disaster have alluded to the possibility that conditions affecting the Texas City refinery may exist more broadly in the industry. This study shows that such assumptions are well founded. Neither the industry nor those who work within it can afford another failure to learn lessons. Further, a failure to seize this opportunity to fulfill the longstanding need to make the substantial improvements in refining process safety outlined here would dishonor the grieving of those who suffered so dearly on March 23, 2005 and after.

REFERENCES


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