

## 4 YEARS ON FROM TEXAS CITY<sup>†</sup>

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Following the tragic Texas City incident in March 2005, the executive leadership of BP reviewed the fundamentals of the company's approach to process safety and operational excellence. This evaluation has led to significant changes designed to improve safety and operations, not just at Texas City refinery, but across the BP group worldwide.

For instance, U.S. Refining has made significant progress with respect to the Independent Panel recommendations, which can be grouped under 4 main headings:

- Leadership
- Integrated and comprehensive process safety management system
- Process safety knowledge and expertise
- Process safety culture

The changes go beyond adoption of the Independent Panel's recommendations, and the paper also discusses other issues, such as competencies, practices/procedures, metrics, and auditing, and highlights some wider messages for the industry.

### INTRODUCTION

The tragic incident at Texas City in March 2005 has many lessons for BP and for the industry, not least in the area of process safety. Over the last 4 years BP has been implementing a comprehensive plan to improve process safety at the Texas City refinery. The company has also conducted a fundamental review of its approach to operations to globally improve all areas of operating performance by applying the lessons learned.

### BACKGROUND

Prior to the incident, BP had benchmarked its HSE management system framework, known as "getting HSE right" (gHSEr), and believed it compared favourably with any in the industry. It defined the company's expectations for managers in many areas including safety and accident prevention, and plant and equipment integrity. It also included minimum standards across the company governing activities like permit to work, energy isolation, ground disturbance, confined space entry, working at height, lifting operations, driving safety and management of change. Frequent audits were conducted of major operating facilities in order to assess compliance with group standards and expectations.

Accountability for safe operations (then as now) was embedded in the line organisationally, and managed at the facility level. Everyone working in a BP facility, including contractors, had a shared responsibility for safety, and was empowered and expected to raise safety concerns and to stop work if they thought conditions were unsafe.

Although the emphasis was upon improving personal (occupational) safety, process safety was not ignored. In 2001 BP established a standard for Process Safety Integrity

Management (PSIM), which was subsequently incorporated into the company's present Integrity Management Standard, published in January 2006. Another process safety improvement initiative was a set of Refining Process Safety Minimum Expectations, which the Independent Panel recognised as "excellent practice".

From 1999–2004 the company's declining injury rates were among the best in the industry with reductions of almost 70 percent in recordable injury rate and 75 percent in fatality rate. There was an ongoing programme to continuously drive up safety standards regardless of the improving record, and the positive trend reflected a concerted, systematic approach to safety.

The combination of performance and external benchmarking led the company to believe that its HSE systems were robust with appropriate levels of control.

### THE INCIDENT

The Texas City Refinery is BP's largest and most complex oil refinery. It has 30 process units that produce gasoline, jet fuels, diesel fuels and chemical feed stocks, and employs about 1,800 permanent BP staff. At the time of the incident approximately 800 additional contractor staff were on site for turnaround work.

The incident has been extensively investigated and reported. BP's own investigation report (ref. 1) was made publicly available on the Internet, and a summary paper (ref. 2) was presented at the 2006 Global Congress on Process Safety. These references contain much more detail of the incident than the brief summary below. CSB also investigated and issued a report in 2007.

As a brief reminder, the incident occurred on the raffinate splitter (the splitter), used for processing gasoline blending components, and involved an associated blow-down drum and stack. The nightshift established levels in

<sup>†</sup>Updated version of a paper presented at the 23rd Annual CCPS International Conference, New Orleans, USA, April 7, 2008.

the splitter using cold feed. They shut off the feed before the end of shift with the splitter level indication showing 100% (10 ft 3 in. in a 164 ft tower). The high level alarm activated and was acknowledged at 72%, but an independent high level alarm (set at 78%) did not activate.

The dayshift on March 23 re-introduced feed and started circulation and heating. The bottoms valve was closed and the splitter became overfilled and overheated. During this period the tower base temperature was increasing but the hydraulic head of cold liquid above meant no fractionation occurred. The splitter level gauge showed a slight decrease as the liquid density changed due to the tower base temperature increasing.

When the operator finally opened the bottom outlet (circa 3 hours after feed restarted) a rapid increase in feed temperature resulted causing vapourisation, and shortly afterwards liquid was released into the overhead relief system.

The relief system was not designed for such high liquid hydrocarbon flows and liquid hydrocarbon was emitted from the blowdown drum and stack. A vapour cloud developed and ignited. The resulting explosion killed fifteen people, injured many others, and damaged property nearby.

## LESSONS LEARNED

The investigation of the Texas City incident involved the collection and analysis of a significant quantity of evidence including witness interviews, control system records, inspection of physical damage, documentation, and equipment testing.

## CRITICAL FACTORS

The evidence was broken down into discrete building blocks of events or conditions from which the critical (causal) factors were identified. Critical factors are those events or conditions that, if removed, might eliminate or reduce the possibility of the incident occurring, or reduce the severity of it. The following critical causal factors were identified:

### Startup and Management Oversight

Failure to follow the startup procedure contributed to the loss of process control. Key individuals (management and operators) did not apply their level of skills and knowledge, and there was a lack of supervisory presence and oversight during this startup.

### Loss of Containment

Actions taken or not taken led to overfilling of the splitter and subsequent overpressurisation and pressure relief. Hydrocarbon flow to the blowdown drum and stack resulted in liquids overflowing the stack, causing a vapour cloud, which was ignited by an unknown source.

### Design & Engineering of Blowdown Drum and Stack

The use of a blowdown drum and stack as part of the relief and venting system for the splitter, after several design and operational changes over time, close to uncontrolled areas.

## Control of Work Area and Trailer Placement

Numerous personnel working elsewhere in the refinery were too close to the hazard at the blowdown drum and stack during the startup operation. They were congregated in and around temporary trailers and were neither evacuated nor alerted.

For each critical factor, possible immediate causes and possible management system causes (root causes) were analysed (see ref. 1). A significant number of possible management system causes were identified indicating many linked issues requiring further evaluation.

## SAFETY CULTURAL ISSUES

In order to understand which recommendations would prevent recurrence it was decided to explore more deeply the underlying safety cultural issues that were identified. The following issues were distilled from the system causes and illustrate a number of lessons learned, some of which will be applicable to a wider cross-section of the industry.

### Business Context

There was a lack of clearly defined and broadly understood context and business priorities for the Texas City site. A clear view of the key process safety priorities for the site or a sense of a vision or future for the long term could not be identified.

### “Safety” as a Priority

Process safety, operations performance and systematic risk reduction priorities had not been set and consistently reinforced by management.

### Organisational Complexity and Capability

Many changes in a complex organisation had led to the lack of clear accountabilities and poor communication, which together resulted in confusion in the workforce over roles and responsibilities.

### Inability to See Risk

A poor level of hazard awareness and understanding of process safety on the site resulted in people accepting levels of risk that were considerably higher than comparable installations.

### Lack of Early Warning

Given the poor vertical communication and performance management process, there was neither an adequate early warning system of problems, nor any independent means of understanding certain deteriorating conditions at the plant.

The BP investigation identified a large number of recommendations specific to the Texas City refinery, and with regard to the splitter and blowdown drum and stack in particular (ref. 1). These recommendations were closely related to the critical factors, management system causes and the underlying safety cultural issues.

### INDEPENDENT PANEL

In response to a recommendation from the US Chemical Safety and Hazard Investigation Board (CSB), BP commissioned an independent panel, chaired by former US Secretary of State James Baker III, to assess the effectiveness of corporate oversight of safety management systems and safety culture at its five US refineries.

The Panel visited all 5 refineries, where they interviewed over 700 staff at all levels and conducted process safety audits. They had access to over 30,000 documents, and conducted a safety culture survey that prompted around 7,500 responses. The Panel's report (ref. 3) was published in early 2007, and its recommendations can be grouped under 4 main headings:

- Leadership
- Integrated and comprehensive process safety management system
- Process safety knowledge and expertise
- Process safety culture

These recommendations contain advice from which the whole industry can learn.

### FOLLOW-UP ACTIONS

The Texas City incident and the Independent Panel findings have had a significant impact on BP. Since the incident in March 2005, the executive leadership of BP has fundamentally reviewed its strategic approach to operations. In January 2007, when BP committed to fully implement the Independent Panel recommendations, the company also set out a clear aspiration: to become an industry leader in process safety management. The agenda to accomplish this goal goes beyond implementing the Panel recommendations but the Panel's insights guidance form a fundamental part of the approach.

The long term strategy to deliver safe, responsible and reliable operations is clear and is founded on the global application of an Operating Management System (OMS) delivered through a continuous improvement approach underpinned by driving consistency through standardisation and sustained by the right organisational capability and operating culture. This strategy was endorsed by the executive leadership team and is now being implemented.

Progress has been made throughout the BP group. Since the Texas City incident, the company has accelerated efforts to improve its safety culture and process safety management. A major increase in executive involvement and leadership has been key to this effort, and significant additional resources have been directed at process safety-related improvements. The first steps by the company in this direction were acknowledged by the Independent Panel, which noted that it had observed significant positive changes at the company during its review.

### TEXAS CITY

The BP incident investigation identified 81 recommendations (ref. 1), and the site leadership team has developed

prioritised plans to address all of them. It is important to remember the scale of BP's operations at Texas City – fundamental change in such an operation cannot be implemented overnight. The average US refinery expends about 3 million man-hours annually. In each of 2006 and 2007 Texas City spent in excess of 18 million man-hours. Much has already been achieved; more remains to be done, and, in reality, BP's commitment to continuous improvement entails a never-ending pursuit of safe operations.

More than \$1 billion has been committed to a 5-year programme to enhance safety, renovate the plant infrastructure, and facilitate cultural change. Among many other things, specific actions include installation of modern process control systems and removal of blowdown stacks. Emphasizing safety and operational integrity, the programme combines, prioritises and coordinates 28 major initiatives that include nearly 600 recommendations and 1,000 specific actions.

The following are some of the accomplishments to date and high priority actions underway:

#### Leadership

A new refinery management team, led by a manager with great industry experience from outside BP has been appointed. A consulting firm was retained to assist with leadership development and support. A new simplified functional organisation has been introduced built around an operations-centric model, so that everyone involved in maintenance and operations knows what they are accountable for and to whom.

#### HSSE Team and Practices

The number of HSE staff at the refinery has trebled with a significant increase in the process safety team. One result is that more qualified people are free to carry out detailed risk assessments as integrated members of operations teams. A rigorous investigation process that includes all incidents, whether they are near misses or actual events, has been implemented. A new site-wide transit system, removing more than 500 vehicles from the site, has been introduced. Expanded community outreach through an extensive community care programme that actively engages with neighbours, local organisations and other members of the local community, has been pursued.

#### Workforce Engagement

The new leadership is changing expectations and engaging the workforce through greater leadership visibility (e.g., gate meets). Changes in work practices, including "Stop" campaign, stand-downs (i.e., "calls to action"), and employee-led PULSE & USW TOP (Triangle of Prevention) programmes have been introduced. Several jobs have been stopped by employees on the spot because of process safety or related issues were identified. New communication practices have been introduced, such as the "Focus on the Future" magazine and weekly "safety meeting in a box".

**Trailers**

More than 200 portable buildings have been removed from the site, and 400+ personnel relocated to offsite offices. A new hurricane-proof employee services building has been constructed outside the perimeter of the refinery.

**Blowdown Systems**

11 blowdown stacks have been removed and new flares installed in line with a new policy of no atmospheric venting of heavier than air light hydrocarbons. A revalidation study of relief valves for all process units, and a relief and flare system review, are being undertaken.

**Inspection & Maintenance**

A top-to-bottom, continuous inspection and evaluation of the refinery has begun. The expanded site inspection programme doubled the number of inspectors. The inspection team’s work has resulted in the replacement of more than 60,000 feet of pipe and more than 2,500 valves. Improved maintenance planning and scheduling has led to visible changes in plant equipment and facilities.

**Control of Work (CoW)**

In light of the significant construction and maintenance programme, a formal risk assessment has been implemented prior to any permitting work. The control of work verification process has been strengthened covering how projects are set up, handed off, overseen and signed-off, including ensuring work is stopped when deviations occur. A trial has been conducted of a new electronic integrated safe system of work (ISSOW) control, in line with BP’s CoW Standard.

**Operating Procedures**

Roles, responsibilities and expectations around startup, operating, and emergency procedures (e.g. raising alarm, evacuation) have been clarified. The site has expanded safety and emergency response drills for operations teams, and it has implemented new site notification and alarm system improvements. Leadership audits have been instituted to verify proper use of startup, shutdown and safe procedures. Pre-Startup Safety Reviews (PSSR) with more detailed checklists requiring formal sign-off have been introduced. Heightened oversight has been achieved by requiring supervisors to be present for all startups, shutdowns and for other safety-critical operations, including requiring written shift handovers with a supervisor present. Exclusion zones have been instituted during unit startups and shutdowns.

**Training/Learning & Development**

Additional development programmes have been introduced including:

- Training programmes for all employees, from orientation for new hires, to commissioning and distillation training, use of simulators, and education on safety and environmental compliance, operations, and operator competency assessment.

- New apprenticeship programme for machinists, and instrumentation & electrical (I&E) technician positions.
- Special leadership training for more than 300 key people at the site.

**Performance Indicators**

A new on-line system for process safety management information has been developed, and is used to focus specifically on process safety in monthly management review meetings with the site leadership team.

**BP GROUP-WIDE**

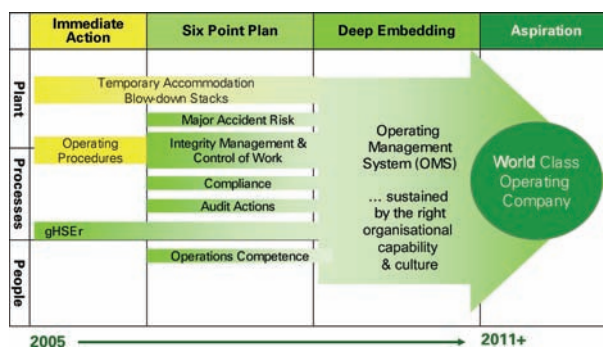
The commitment to significantly improve process safety management is a global one. No part of BP is unaffected. Thus, as previously stated, the strategic review of operations across the BP group has been broader than any single activity at Texas City. This review has been informed by the Independent Panel’s recommendations. Actions have been prioritised to achieve early risk reduction and integrated into existing/future plans and systems. There has been much activity, but it has been planned to try and avoid over-stretching the workforce or creating confusion with ill-conceived actions. Care has been taken not to launch waves of new activity, but rather to take carefully considered and targeted actions for improvement that engage front-line operations.

**The Path Forward**

The overall approach to improving safety culture and process safety management throughout the company is illustrated in the diagram below (Fig. 1). It addresses immediate risks, intermediate actions, and then a longer term approach under the Operating Management System (OMS). This approach is not an “initiative”, but a long-term plan to excellence with the OMS as core.

The approach is based upon focus on, and delivery of, a few key group-wide activities around **Plant**, **Process** and **People** that should in turn achieve continuously improving compliance, risk management, and overall results, i.e., **Performance**. These are known as the “4 Ps”.

Certain immediate actions were put in place soon after the Texas City incident, which included the



**Figure 1.** The path forward

establishment of the Safety and Operations (S&O) function to support line management. Part of the role of S&O is to transfer learning. This initial response was aimed at addressing compliance and major risks in the areas of health, safety, environment and operations.

During 2006, safety and operations integrity was confirmed as the top priority for the company and a ‘Six-Point Plan’ clarified the immediate priorities for BP operations on a worldwide basis. The Plan addresses the main learnings from the company’s investigation and has some specific, measurable commitments. For example, all businesses and operations across the BP group were required to complete Major Accident Risk assessments, begin implementing improvement plans and evaluate the competence of their teams in matters of safety and operations.

Other actions involved removing temporary buildings and blowdown stacks in heavier-than-air light hydrocarbon service, implementing the new Control of Work and Integrity Management Standards, and rapidly closing out outstanding actions from past audits. The Plan also re-committed all BP facilities worldwide to a pre-existing requirement to comply with all laws and regulations relevant to their operations and to enhance their processes for verifying compliance. The company is tracking efforts to meet these continuing objectives.

The longer-term plan is based on OMS, which incorporates gHSEr, is based on the ISO management system framework, and will help drive continuous improvement. OMS is an integrated and comprehensive management system for operations and HSE, including process safety, and is designed to support a more rigorous approach to safety and operations compliance and risk management. It is underpinned by the group-wide Control of Work and Integrity Management standards and detailed practices in matters such as risk assessment, incident reporting and incident investigation. OMS is being introduced in phases with the a number of sites in first wave of implementation having transitioned to the new system. The learnings from this first wave have been used to improve the system documentation and to help plan more effective implementation throughout the rest of the company.

#### Leadership

Leadership has consistently communicated the strategic imperative of ‘safe, reliable operations’, and the focus on safety, people, and performance has been reinforced at all levels in the company. For example, BP CEO Tony Hayward has repeatedly reinforced to all BP staff: that “safe, responsible and reliable operations are the number one priority in BP”.

A major structural change concerned the establishment of the Group Operations Risk Committee (GORC) to provide assurance that operational risks are identified and managed in accordance with approved Company policy. The GORC is chaired by the CEO, and membership includes the business segment chief executives and senior functional expertise. It meets regularly to oversee and build a

foundation for consistent, safe, reliable operations, and regularly communicates direction to the Group, including:

- Incident analysis, learning and response
- Monitoring performance indicators
- Reviewing delivery of the 6-Point Plan
- Oversight of development and implementation of the OMS
- Oversight of HSE and operations capability development
- Independent Panel response and the integration of that response into plans and OMS

The initial focus was on ‘essentials’ such as major hazard identification and risk reduction. While the focus remains on major risks, the emphasis has been moving towards overseeing implementation of OMS and capability building programmes.

The engagement of senior executives in the agenda has been a significant step in meeting the Independent Panel’s first recommendation, which encouraged Executive Management to provide effective leadership in process safety.

Another significant leadership change involved strengthening BP’s US regional organisation with the appointment of a new president, reporting directly to the CEO, to oversee safety, operations integrity, compliance and ethics within the USA.

#### Performance Measurement

An important tool to assist the GORC in their oversight has been the development of the quarterly HSE and Operations Integrity Report. This report comprises comprehensive management information for monitoring leading and lagging indicators of performance associated with safety and operations, as well as delivery of the 6-Point Plan. The selection of these performance indicators has been influenced through involvement in the CCPS Process Safety Metrics project (ref. 4), and by work at BP’s Hull chemical site with the UK Health and Safety Executive (ref. 5).

These data are routinely reviewed and allow GORC and the business segment executive teams to view activity at an operating unit level, track progress to close-out, and receive feedback on barriers to successful completion. The company now has better management information to support the delivery of its strategic plans. This improvement demonstrates key progress against another of the Independent Panel recommendations directed to Executive Management.

#### INDEPENDENT PANEL RECOMMENDATIONS

In January 2007, BP committed to fully implement the Independent Panel’s recommendations, and significant progress has since been made across all of the recommendations, which, as already noted, can be grouped under 4 main headings:

- Leadership
- Integrated and comprehensive process safety management system

- Process safety knowledge and expertise
- Process safety culture

#### Leadership

In addition to the leadership activities previously discussed, the senior executive team has increased its visibility through regular visits to refineries and other major production sites. The executive team also attended a 2-day operations training session at MIT in 2007 and again in 2009. Changes to performance contracts and remuneration for senior leadership include focus on process safety measures. An independent expert reporting directly to the Board has been appointed.

Resources have been focused on operations with a plan to increase spending (from about \$1.2 in 2005 to average of \$1.7 billion/yr through 2010) to improve integrity and reliability of the U.S. refineries, and experienced engineers have been deployed to specific refineries. A new central audit team has been established within the S&O function, acting as part coach as well as part “cop”, with over 60 experienced operations and engineering personnel. This team has already undertaken a significant number of more rigorous safety and operations audits, and by the end of 2009 will have audited over 100 operations including all of BP’s U.S. refineries.

#### Integrated Management System

At the U.S. refineries, risk prioritised plans have been developed to address Independent Panel recommendations directed to the U.S. refineries. The previously described performance measures and more rigorous auditing form important parts of these plans. The sites are making good progress in implementing the OMS with more than 10 operations globally, including Toledo Refinery the the US, now transitioned to the new system.

#### Process Safety Knowledge and Expertise

Safety and Operations functional teams at group and refining business levels have been strengthened to improve professional focus and provide more support to operating sites. Senior process safety appointments have been made at group and refining business levels. Process safety specialists from a major consultancy have been deployed in the U.S. refineries to assist with action item closure and acceleration of priority improvement programmes.

A number of training and awareness programmes have been implemented to improve process safety knowledge and understanding. An Operations Academy has been established with MIT since 2006 for the top operations managers in the company, and process safety is an important part of the curriculum. Other training classes are targeted at project managers/leaders, and front line operations leaders. A process safety fundamentals training course has been developed for all discipline engineers and HSE professionals. A system of capability assessments for Operations leadership teams is being implemented.

#### Process Safety Culture

Some important progress has also been made in the area of organisational culture with regard to safety and operations. Executive leadership has committed to build a culture that puts operations at the centre of all activity. The Independent Panel’s process safety culture survey findings were shared with the U.S. refining workforce, and a repeat cultural survey at the U.S. refineries identified significant progress at all sites.

Additionally, a safety culture assessment tool has been developed with support from specialised researchers; it has been informed by rigorous statistical analysis and input from other ‘best in class’ practitioners. The assessment provides an opportunity for the organisation to look at factors more deeply and to better understand priorities for improvement. Following a series of pilots, which established the usefulness and credibility of the tools, the safety culture assessment and improvement process is being implemented at various sites, including Toledo and Texas City refineries in the US.

Part of the cultural change involves a closer working relationship between the company and organised labour. A 10-Point Plan to improve safety in BP’s U.S. Refining operations has been jointly developed with the United Steel Workers (USW) and comprises the following:

- BP will promptly address the immediate causes of the Texas City tragedy throughout the corporation.
- BP and the USW will establish joint process safety teams.
- BP and the USW will establish a joint programme for accident and near-miss investigations, and for reviewing safe operating procedures.
- BP and the USW will work together to upgrade safety education programmes.
- BP will ensure that its facilities are adequately staffed and that employees have reasonable hours of work.
- The chief operator position will be re-established, where it does not now exist, so long as it enhances safety in the refineries.
- BP will ensure adequate internal maintenance work forces.
- BP will work with the USW and appropriate community officials and organisations to ensure that the company is a good environmental neighbour.
- BP and the USW will define and ensure effective teamwork in the refineries.
- BP and the USW will establish a structure for implementing and overseeing this initiative.

Greater transparency, clearer accountability and improved communication have a central role to play in any sustained improvement in process safety performance and also in rebuilding trust with the outside world. In terms of engagement, we have committed to improved two-way discussion with our employees about process safety. To this end, dozens of “town hall” meetings have been held all over the world related to Texas City and

process safety. Executive leadership are also spending a lot of time listening

As previously described, to support all of this, programmes are being developed that will improve leaders' understanding and competency in how to build and strengthen safety culture within the organisation.

## CONCLUSIONS

The lessons from Texas City hold significant learnings not only for the rest of the BP group, but for the whole industry. BP is determined to make a concerted and lasting improvement in process safety. Safe, responsible and reliable operations are, and will continue to be the number one priority. However the company is not starting from scratch. The existing strong focus on personal safety and environmental care, with declining personal injury rates among the best in industry, is being applied to process safety. Much progress has been achieved, but more is still to do. It is a long journey – indeed, BP's commitment to continuous improvement will never really end.

It is recognised that success requires an integrated approach that addresses not only the plant, but equally importantly *how* things are done more consistently, and how the right levels of skills, competence and behaviours are developed to create the culture needed to become a world class operator. *All* areas of operating Performance need to be examined and improved through an intense and lasting focus on the other '3 Ps' of Plant, Process, and People. This will require an integrated, disciplined and sustained approach that encompasses each of these areas, delivers enhanced levels of consistency, and is implemented across all BP's global operations at a sensible pace.

The Texas City incident was preventable. The lessons learned from the incident can help prevent others from repeating mistakes. It is encouraging that many within the industry are engaged and taking positive actions to ensure that these lessons are learned. It is hoped that the content of this paper will sustain this progress and continue to spread the learning.

The authors would like to thank BP for permission to publish this paper.

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