Refining Human Factors

Whilst human factors issues feature strongly in the recently published Baker and CSB reports on BP's US refineries, Bill Gall of Kingsley Management challenges whether they identify any new issues. In this article he maps an analysis of the issues against a set of key human factors issues used by the Energy Institute's (EI) Human and Organisational Factors Working Group as the framework of its technical work.*

The remit of the Independent Safety Review panel led by James Baker was to review the issues of safety management, safety culture and safety oversight at BP's five refineries in the US. The CSB investigation sought to identify the root causes of the explosion and fire at BP's Texas City complex and to make safety recommendations to plants, industry organisations, labour groups and regulators. The Baker report at 374 pages and the CSB report at 337 pages present a somewhat daunting read – but it repays the effort to at least scan their summary, recommendations and findings sections. These in themselves provide a fascinating insight into how a large sophisticated organisation can fail in its safety mission at a very basic level. They also serve as a reminder of the purpose, scope and appropriate use of human factors as a discipline.

Human factors is a hybrid discipline that uses theories and constructs from other subjects that help us understand and improve human performance – its principles, standards and techniques are not simply 'common sense', although most of its subject matter is not complex.

To make use of human factors knowhow – which incorporates ergonomic design as well as safety management and safety culture elements – we must recognise it as a powerful management tool, have belief in the subject and apply effort to integrate and utilise its data and technologies within our organisations.

The purpose of this article is to use the findings of the Baker panel and CSB reports to illustrate that the issues they raise are well-known and to describe some of the resources that are readily available for addressing them. The Baker report (*The Report of the BP U.S. Refineries Independent Safety Review Panel*) is available to download from **http://www.safetyreviewpanel.com/ .**The CSB report *(Investigation Report Refinery Explosion and Fire BP Texas City, Texas, March 23 2005*) is available for download from **http://www.csb.gov/completed_investigations/docs/BP%20Final%20Report%203.23.07.pdf**

EI Working Group

In the summer of 2001, the EI formed under the Technical Department's safety theme, a Human Factors Working Group – recently renamed the Human and Organisational Factors Working Group to reflect its broader remit. Its objective was, and remains, 'to help the energy industries to better understand and apply human factors approaches to their operations with a view to further improving safety performance'. To achieve this aim, the Group has sought to identify,

develop and make available useful, industry-relevant information on the subject of human and organisational factors.

The Working Group has convened seminars and workshops to disseminate knowledge and good practice, and, using funding from the EI's Technical Partners and stakeholder co-funding, it has commissioned the writing of 'briefing notes', safety information bulletins and guidance on key subjects. The Working Group comprises human factors specialists representing the breadth of the industry and also the UK Health and Safety Executive (HSE).

Much of the Working Group's output is freely available from the EI at **http://www.energy.org.uk/humanfactors** and extensive supporting material can also be found on the HSE's website at **http://www.hse.gov.uk/humanfactors/index.htm**

As a starting point, the Working Group developed resources focused on the HSE's key human factors issues. These are persistent shortcomings that HSE inspectors have identified in site inspections and audits across a wide range of industries. In response to Member needs, the Working Group also commissioned additional guidance on some specific issues of concern, such as fatigue, and on human factors techniques such as task analysis and staffing assessment.

Table 1 describes the key issues and indicates where the Baker panel and CSB investigation findings relate to them. The key issue of 'safety management' in the Working Group's resources is broken down into specific issues such as organizational change, communications, safety critical procedures and human factors integration. The resources provide forward reference to other key information sources on safety management, notably HSE *Successful health and safety management* (HSG65).

None of the resources developed by the Working Group is particularly 'new' in the sense of being derived from original research, but nor are the issues that have been raised in the Baker and CSB reports.

Table 1: Key human factors issues

Numbered items are issues covered by EI Human and Organisational Factors Working Group (see: **http://www.energyinst.org.uk/humanfactors/topten**).Relevant quotes from the Baker report are provided in italics, followed by associated page number preceded by a B; those from the CSB report are in plain text, page numbers preceded by a C. For the sake of brevity, selected quotes from the reports are given in the table. In the case of the CSB report, these are mainly taken from the key findings section of the report. Square brackets indicate commentary text.

1. Organisational change
Most of BP's five U.S. refineries have had high turnover of refinery plant managers, and process safety leadership appears to have suffered as a result (B74) BP Texas City did not effectively assess changes involving people, policies, or the organisation that could impact process safety (C26)
2. Staffing arrangements and workload
BP has not always ensured that the resources [including human resources] required for strong process safety performance at its five U.S. refineries were identified and provided (B85) *BP's corporate initiatives have overloaded personnel (B86)* An extra board operator was not assigned to assist, despite a staffing assessment that recommended an additional board operator for all ISOM startup (C23) Startup and upset conditions significantly increased the ISOM Board Operator's workload on March 23, 2005, which was already nearly full with routine duties, according to BP's own assessment (C84)
3. Training and competence (and supervision)
BP has not effectively defined the level of process safety knowledge or competency required of executive management, line management above the refinery level and refinery managers (B152) *BP has not adequately ensured that its U.S. refinery personnel and contractors have sufficient process safety knowledge and competence (B163)* *At most of BP's U.S. refineries, the implementation of and over-reliance on BP's computer-based training contributes to inadequate process safety training of refinery employees (B164)* A lack of supervisory oversight and technically trained personnel during the startup, an especially hazardous period, was an omission contrary to BP safety guidelines (C23) The operator training program was inadequate. The central training department staff had been reduced from 28 to eight, and simulators were unavailable for operators to practice handling abnormal situations, including infrequent and high hazard operations such as startups and unit upsets (C23)
4. Fatigue (from shiftwork and overtime)
Operations and maintenance personnel at BP's five U.S. refineries sometimes work high rates of overtime (B89) ISOM operators were likely fatigued from working 12-hour shifts for 29 or more consecutive days (C23) [The EI recently published a guidance document on fatigue and alertness *'Improving alertness through effective fatigue management'* – available free from **http://www.energyinst.org.uk/humanfactors/fatigue**]
5. Human factors in design
[Outside Baker Panel's remit] The following underlying latent conditions contributed to the unsafe start up: …Malfunctioning instrumentation that did not alert operators to the actual conditions of the unit (C69) A poorly designed computerized control system that hindered the ability of operations personnel to determine if the tower was overfilling (C70) On the day of the incident, however, the computerized control system display provided neither flow data in and out of the raffinate unit on the same display screen, nor a material balance calculation (C97) Critical alarms and control instrumentation provided false indications that failed to alert the operators of the high level in the tower (C21)
6. Procedures (especially safety critical procedures)
[Outside Baker Panel's remit] Outdated and ineffective procedures did not address recurring operational problems during startup, leading operators to believe that procedures could be altered or did not have to be followed during the startup process (C23) BP management allowed operators and supervisors to alter, edit, add, and remove procedural steps (C74)

7. Organisational culture (and development)
BP has not established a positive, trusting, and open environment at some of its U.S. refineries… (B79) [the findings on leadership and accountability (pages B65, B68, B80, B94 and B234) also concern key aspects of safety culture] *Each of BP's five U.S. refineries has its own separate and distinct process safety culture. Some are far more effective than others in promoting process safety, but significant process safety culture issues exist at each of BP's five U.S. refineries, not just Texas City (B119)* *Instances of a lack of operating discipline, toleration of serious deviations from safe operating practices, and apparent complacency toward serious process safety risks existed at each of BP's five U.S. refineries.(B126)* *The BP Board of Directors did not provide effective oversight of BP's safety culture and major accident prevention programs. The Board did not have a member responsible for assessing and verifying the performance of BP's major accident hazard prevention programs (C25)* *Reliance on the low personal injury rate at Texas City as a safety indicator failed to provide a true picture of process safety performance and the health of the safety culture (C25)* BP Texas City lacked a reporting and learning culture. Personnel were not encouraged to report safety problems and some feared retaliation for doing so (C26)
8. Communications and interfaces
(B79 continued)…with effective lines of communication between management and the workforce, including employee representatives *BP's executive management either did not receive refinery-specific information that suggested process safety deficiencies at some of the U.S. refineries* *or did not effectively respond to the information that they did receive (B231)* Supervisors and operators poorly communicated critical information regarding the startup during the shift turnover; BP did not have a shift turnover communication requirement for its operations staff (C24) On the morning of March 23, the raffinate tower startup began with a series of miscommunications (49)
9. Integration of human factors into risk assessment and investigations (including safety management systems)
BP's safety management system does not ensure adequate identification and rigorous analysis of process hazards at its five U.S. refineries (B137) *BP's safety management system does not ensure timely implementation of external good engineering practices that support and could improve process safety performance at BP's five U.S. refineries. (B148)* *BP does not ensure that identified process safety deficiencies at its five U.S. refineries are addressed promptly and tracked to correction (B220)* BP had not implemented an effective incident investigation management system to capture appropriate lessons learned and implement needed changes. Such a system ensures that incidents are recorded in a centralized record keeping system and are available for other safety management system activities such as incident trending and process hazard analysis (PHA). The lack of historical trend data on the ISOM (C100)…
10. Managing human failure (including maintenance error)
BP's safety management system does not ensure timely compliance with internal process safety standards and programs at BP's five U.S. refineries (B144) *BP's process safety management system does not effectively:* *(1) translate corporate expectations into measurable criteria for the management of process risk, or* *(2) define the appropriate role of qualitative and quantitative risk management criteria. (B172)* [Further managing human failure (including maintenance error) findings on pages B173, B176, B196, B213] *Neither BP's executive management nor its refining line management has ensured the implementation of an integrated, comprehensive, and effective process safety management system for BP's five U.S. refineries (B231)* *Numerous underlying latent conditions collectively influenced the decisions and actions of the operations personnel at the AU2/ISOM/NDU complex.* *These safety system deficiencies created a workplace ripe for human error to occur (C99)* *…Texas City refinery management agreed to implement a number of cost-reduction actions that affected training, including:…* *•reducing the training plan for outside operators and maintenance crafts…(C96)*

Process safety vs. personal safety

A key issue arising from the Baker and CSB reports is absent from the above table. It is illustrated in the following quotes:

BP has emphasized personal safety but not process safety (B71)
…a very low personal injury rate at Texas City gave BP a misleading indicator of process safety performance (C19)

BP mistakenly used improving personal safety performance (i.e., personal injury rates) as an indication of acceptable process safety performance at its five U.S. refineries; BP's reliance on this data and inadequate process safety understanding created a false sense of confidence that it was properly addressing process safety risks at those refineries (B72)

The debate over process versus personal safety has gone on for some time but recently, there seems to be more concern among human factors specialists that organisations fail to understand the issue. One element that seems central to this concern is the 'accident triangle' or 'accident pyramid' approach to safety improvement. Heinrich's research published in 1931 and is often quoted as the starting point for this approach but his findings have been supported by later studies. The numbers may differ slightly but Heinrich's examination of a large amount of incident and accident data suggested that, for every 300 'unsafe acts' encountered in an industrial plant, there will be 29 minor injuries and one major injury.

The 'total loss' approach suggests that, by reducing the 300 unsafe acts, then there will be a corresponding reduction in major and minor injuries. The problem with this approach is that organisations often go for the 'easy wins' and will produce initiatives to reduce, for example, driving accidents or occupational slips, trips and falls. These are important and they are common, but this focus can lead to major hazard organisations taking their eye off process safety and the arrangements that need to be in place to reduce the incidence of low probability high consequence events. There are undoubtedly many common underlying influences on personal and process accidents, but we need to be very clear what they are and, importantly, where the differences lie.

To quote from HSE guidance on introducing behavioural safety programmes, 'Don't believe that the 'Heinrich triangle' works for occupational ill-health, minor personal injuries and major accidents'. http://www.hse.gov.uk/humanfactors/comah/behaviouralintor.htm

Better understanding human failure in incident/accident investigations

One finding in Table 1 is that, *BP's investigation system has not instituted effective root cause analysis procedures to identify systemic causal factors (203)*

Without such investigation, it will not be possible to establish the causal links between different types of event.

The Energy Institute's Human and Organisational Factors Working Group has recently commissioned the development of guidance on investigating human factors aspects of incidents and accidents. This guidance will describe the most useful available methods for identifying the underlying human factors and organisational causes of incidents and accidents. It will describe, among other things, how to obtain these methods, their basis, the type of information they can generate and the required competencies of the target user. See http://www.energyinst.org.uk/index.cfm?PageID=1127 In addition, the Working Group is commissioning a research studentship that aims to identify and test the factors that promote 'deep' rather than 'surface learning' from incidents.

**Kingsley Management is a human factors consultancy specialising in human reliability analysis and the development of human factors guidance including the IP Human factors briefing notes and HSE COMAH guidance material.*