If companies are to avoid repeating accidents, engineers need time and space to use the tools at their disposal, says **Mohan Karmarkar**

IN spite of the fact that there is ample information on past incidents, we somehow keep repeating the same mistakes again and again. Safety guru Trevor Kletz has given our community more than enough warnings about how organisations develop a short memory. But many reputable firms that had developed good engineering standards and procedures based on the experience of their staff seem to have discarded the in-house standards for international standards, ditched the staff and turned to outsourcing in a bid to reduce cost.

Recently, Richard Gowland offered similar warnings in his article *Uncovering the unknown* (***tce*** 861). Rightly, he identified the need to consider not only the 'known unknowns' and the 'unknown knowns' but also the 'unknown unknowns' in light of the Texas City, Fukushima and Gulf of Mexico incidents.

Meanwhile, it's very rare that accidents are repeated in the aviation industry where there is greater acceptance of the need to learn from mistakes. There is openness in the way aviation accidents are investigated and reported. Consequently, the aeronautical engineering sector spends sufficient time in the design stage, thorough testing is carried out, and the regulatory authorities' approval process demands safety first ahead of any business necessities. So why is the rest of engineering industry less safe?

It's not just lack of corporate memory and knowledge of the 'unknown unknowns' that lead to accidents being repeated. Looking at how projects have been carried out in various sections of our industry over the past 40 years, we also see business drivers, engineering execution, and reliable data sources playing their part. Do the following scenarios sound familiar?

business drivers

A project proposal or a new commercial opportunity comes in front of a company's board of directors. Do they ever consider the impact of health, safety and environment (HSE) on the proposal? All they appear to

be concerned with is the market forecast, the cost and schedule, and the likely profit/loss of the new venture. A budget is assigned to the project based on the board's experience of similar projects and the timetable for delivery is set. Therefore, the only time HSE is considered is when the go ahead is given and the engineering department is asked to prepare the design and provide a cost estimate to ±10%, according to delivery date. The assigned project value is not disclosed to the engineers.

It's worth remembering that a project follows several phases during its execution, depending on its type. For example we have conceptual design, process design package, licensor package, invitation to bid, detail design, construction pre-commissioning and commissioning before a plant starts production. Therefore each project has a certain timeline for the delivery of the final plant.

With due diligence the engineering department carries out the initial design work and prepares the estimate for all the combinations of product grades that have been asked for by the commercial forecast – which is only ±50% accurate at most. Engineers use all the tools that are available to carry out preliminary HAZID and project challenges to eliminate any major obstacles and the cost estimate is finalised based on the initial design. Invariably, the cost comes out high, and when it's discussed at the next board meeting it's sent back to the engineering department with the instruction to reduce it. The engineers set about cutting the costs by reducing the scope, performing value engineering and maybe taking some risks with material selection.

It then goes back to the board and is discussed at the next board meeting. The board members in their wisdom decide that it should not cost *that* much, because something similar was installed on another plant in a different country a few years back and only cost 60% of what was estimated so allowing for inflation and so on, the board decides that the project will be allocated 80% of what was estimated. By this time, 6–8 months or more have passed, but the project end date remains the same – yet the engineers are expected to deliver to the allocated budget and schedule, both of which have been cut.

How do engineers then achieve this new target? Everything is now on a critical timeline. The schedule for all activities is shortened irrespective of whether it can be achieved or not. Construction starts before design is completed. The project manager calls for out-of-phase engineering to shorten the project duration.

The situation has now become very difficult for the engineers and it's not likely to improve if they challenge it. For example, few young engineers can stand up to management and state that the HAZOP schedule is impossible to complete to standard in case they are shown the door. If they are bold and say so, the HAZOP may then be divided into parallel sessions to meet the compressed schedule. Now the plant design is changed so many times that it does not have any similarity to the original design. Two reactor trains have been reduced to one of slightly larger capacity, product grades have been cut from 10 to 4. Everybody understands the construction time is necessary but process design time can be reduced easily by allocating extra engineers, and working overtime, and so now it's possible to reduce the allocated process design time even further. As the design progresses, the man-hour costs increase above the budget and so overtime is cut – with the instruction to make do with the available time and reassign some engineers to other duties.

Meanwhile, the commercial scene has changed and the commercial forecast is now to add a new product requirement for which the board sanctions extra money and engineers are asked to make the necessary change.

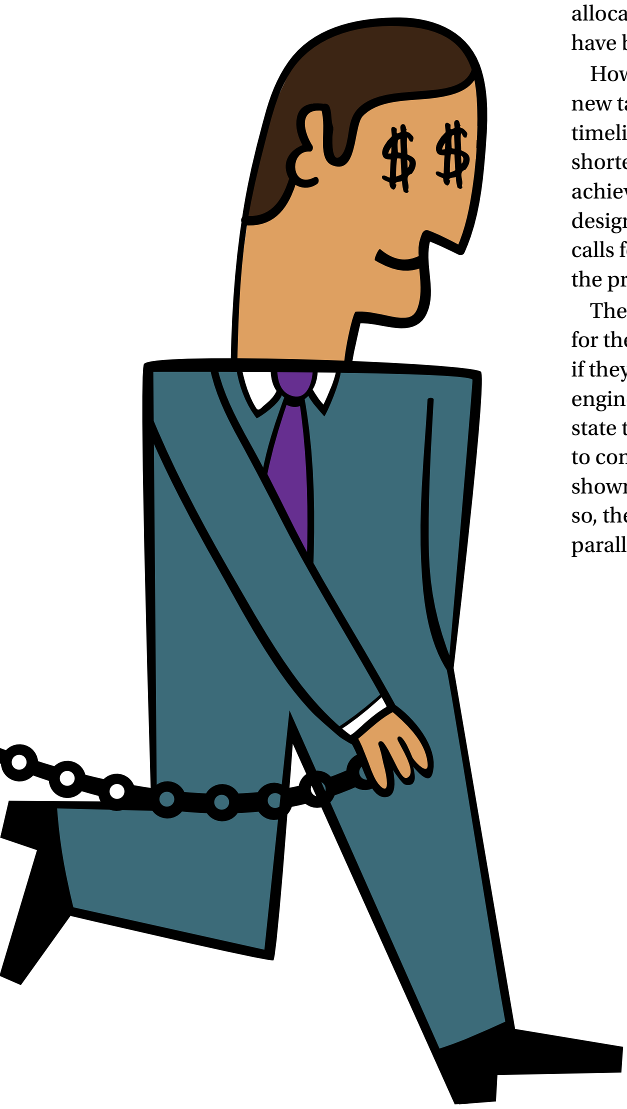
But the end date remains the same. Extra engineers who were not involved with the initial project and do not know the history of the changes and constraints of the site are drafted in to carry out the additional work.

The plant is erected, modifications are made during construction, and it's handed over to be commissioned. This is when the problems start. These are patched up and the plant is handed over to the production department, which now has the unenviable task of producing the product slate safely.

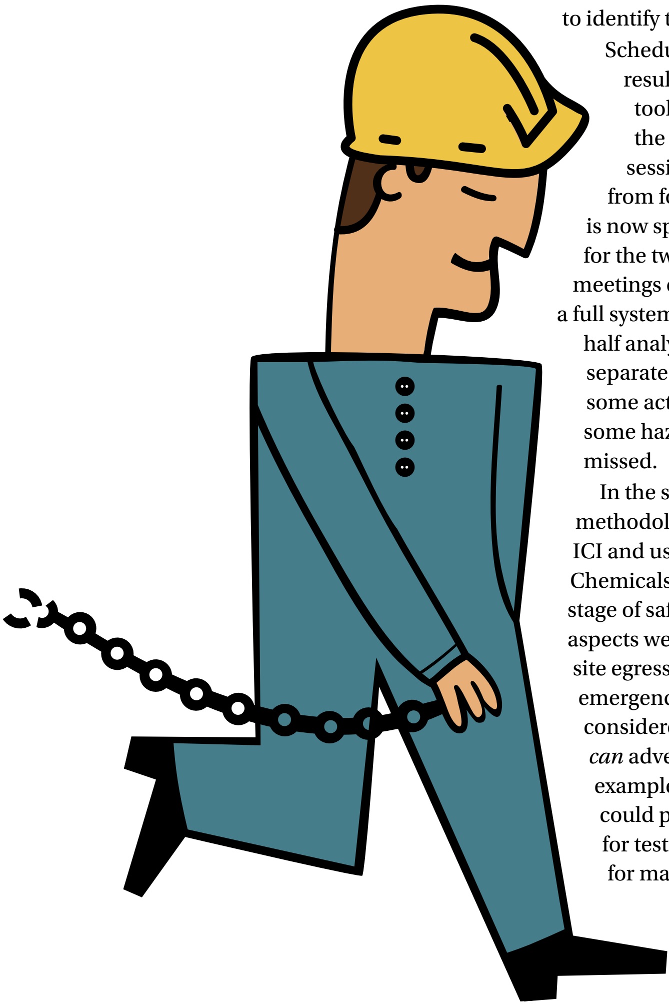
Is it surprising that we end up repeating the same mistakes and accidents reoccur? Of course, not all stages in this scenario occur in every project, but any one of them – or a combination – could result in difficulties leading to repeat accidents.

engineering

Engineers have all the necessary tools to ensure any plant built is safe to operate, and causes no harm to people or the environment. These can be varied, and include HAZID, HAZOP, bow-tie, and so on. So why do we fail



Led astray



to identify the 'known unknowns'?

Schedule and cost constraints can result in the wrong set-up for these tools. For example, in our scenario, the HAZOP is now set up in parallel sessions to reduce the HAZOP time from four weeks to two. The plant is now split up in 'reasonable' packets for the two HAZOP teams to analyse in meetings conducted simultaneously. So a full system is divided in two, with each half analysed by a different team in two separate meeting rooms. No wonder some actions fall through the gap and some hazards of the whole system are missed.

In the six stages of safety review methodology (as originally formulated by ICI and used extensively at the likes of BP Chemicals), HAZOP was one part of a third stage of safety review in which all other aspects were also considered – for example site egress/access, building design safety, emergency vehicular access. These aren't considered in the process HAZOP but *can* adversely affect process safety. For example, building design constraints could prevent access to relief valves for testing and leave insufficient room for maintenance. HAZOP alone is insufficient to identify such outside influences.

Another problem is that most of the time, operating and maintenance staff are unavailable to attend such meetings as they have production pressures. This can result in missing out on the provision of correct identification of equipment isolation requirements for inspection and /or maintenance.

LOPA analysis identifies the SIL levels and the necessary required/assumed testing requirements. Do the plant operations and maintenance personnel know the exact such requirements for all of the plant and do they adhere to it? Often, the plant operating and design manuals cannot be located quickly by the operators. These either languish in the main office or in some filing cabinet somewhere on plant in someone's office.

Value engineering – the relationship between functionality and cost – can be a useful tool to engineers, if used correctly. However, the temptation is to use it to solely reduce costs, and this could lead to mistakes. For example, the sinking of an oil platform in which value engineering had saved about US$200m of construction costs (by reducing the support structure requirement) resulted in the loss of a platform worth US$600m.

Value engineering has its place in challenging project assumptions and eliminating 'nice to haves' and optional extras, as well as encouraging innovative designs but it needs to be carried out on sound engineering judgement and on the proper selection of choices presented, not just based on cost.

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data sources

At one time IChemE used to keep an *Accident Database* that engineers would consult as part of their HAZOP procedures. A lack of funding led IChemE to stop updating the service and the archived materials remain available to buy only on CD.

Engineers are turning to electronic search engines but search results seem to go back no further than 20 years. Consequently, even experienced consultants are missing the mistakes that have already been made.

IChemE publishes the *Loss Prevention Bulletin* (*LPB*) which is an excellent source on past accidents but how many from industry subscribe to it? I'd like to see IChemE doing more to share this knowledge. It should make presentations to boards showcasing the value of *LPB* and I'd like to see it consult on reviving the much-needed *Accident Database* – perhaps seeking sponsorship from industry.

IChemE could also get other institutions involved in both sets of activity to give it more credence and convince company boards to take more notice of HSE.

a route to prevention

No amount of development of analysis methodologies will prevent accidents from being repeated but an awareness of the need for proper set-up and a reasonable schedule to perform each activity is essential so that the engineers can have some chance of identifying 'known unknowns' and possibly 'unknown unknowns.'

Only in this way can manufacturing operations and the environment be protected properly. **tce**

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