

A lifetime spent saving lives

Trevor Kletz, the father of inherent safety, explains his remarkable career

WHEN it comes to the topic of process safety, the one name that comes to mind instantly is that of Trevor Kletz.

One of the first people to be given a new kind of position – that of technical safety advisor – in the 1960s, it was Kletz who developed the concept of inherent safety. First set out in the article “What you Don’t Have Can’t Leak”, published in *Chemistry & Industry* in 1978, the concept postulates that the best way to reduce risk is to avoid the hazard rather than control it, ie by designing it in a way that minimises the use of dangerous substances or processes.

The idea was at odds with conventional thinking at the time, which centred around safety devices designed to control accidents, but it was nevertheless well received. “The feedback I got at the time was very positive,” Kletz confirms. Indeed, leading regulators worldwide have since embraced the concept, and agencies including the Health and Safety Executive, the European Commission and the US Nuclear Regulatory Commission have enshrined the principle through regulations such as COMAH and the Seveso II Directive, both of which recommend applying the principle of inherent safety to avoid or reduce hazards at source.

a chemistry set with consequences

Kletz became interested in process safety by experiencing first hand how a process plant works and the hazards it can represent. Born in 1922 as the oldest of three children, his father, a shopkeeper, was insistent that young Kletz should better himself and go to university. “When I was 11 years old, an uncle had given me a chemistry set as a present. When I arrived at university there was no doubt I’d study chemistry.” Living in Chester, Liverpool was closest – so Kletz attended Liverpool University.

After graduating in 1944, he got an offer to join ICI in Billingham in its research labs. “I considered myself very lucky – ICI was considered a very good employer and

you’d have to be foolish to turn them down.” Kletz was to stay at Billingham for the whole 38 years he spent with ICI.

no test tube in sight

“When I joined I expected to be spending my life pouring liquids from one test tube into another – but I actually never touched a test tube in the whole time I was there!” he says. “ICI’s research department was far more concerned with solving engineering problems.” Seven years of solving chemical engineering problems steadily moved Kletz away from chemistry and towards chemical engineering. “It isn’t as if I ever took a formal degree in chemical engineering, I just became one without even realising it,” he says.

managing plants and people

After seven years, Kletz was promoted to plant manager – very much a hands-on job. Over the next 16 years, he would be running plants and troubleshooting problems, working his way through a succession of iso-octane, acetone and tar acids plants. This gave him the opportunity to learn first-hand how the plants operated, from the shop floor up. “The iso-octane plant to which I was first assigned had been operating for 12 years, the shift foremen were experienced. Everything that could go wrong had gone wrong before so the foremen knew exactly what to do and just got on with it, despite the lack of any up-to-date operating instructions (something I was to remedy),” Kletz wrote in his autobiography, *By Accident*.

Kletz not only got a detailed first-hand view of how a chemical plant was operated, he also learned how to influence people, how to identify the ‘gate-keepers’ for a given job, and how to get them on side. “The technique is



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good-natured persistence – you have to keep on lobbying and persuading until your job is done,” he wrote. It was a skill he would put to good use in later life.

Kletz’ first formal safety assignment came in 1955, when he was named part-time safety officer at ICI’s Oil Works. But there was no realisation at the time that safety required a technical input or should go much beyond removing obvious mechanical hazards and ordering protective clothing, and Kletz concluded that safety was dull.

the birth of HAZOP

Kletz has sometimes been credited with developing the concept of HAZOP, but that’s not true. HAZOP grew out of ‘critical examination’, a technique popular with ICI during the 1960s for examining management decisions. Ken Gee, a production manager with ICI, decided to apply this technique to the design of a new phenol plant and, over a four-month period, spent three days a week, every week, examining every aspect of the plant, discovering many potential hazards and operating problems that would not have been foreseen otherwise. It was, Kletz says, the first recognisable hazard and operability study (HAZOP).

“At the time I was too busy running the existing plants to take much interest in the new one,” he wrote. “Later, when I took the full-time safety job I became an enthusiastic advocate of HAZOP.”

the safety advisor

The position of technical safety advisor was a step in a new direction for ICI, prompted by unhappy necessity. “We had several years where ICI suffered accidents, and five people were killed in three years on the North Tees Works alone. Ken Gee, who’d been promoted to production director, convinced the board that it needed someone with a technical background to focus on safety. As I’d shown more interest in that side of my work than many other people I was asked to prepare a job description – one which my boss at the time said specified one Trevor Kletz.”

Kletz’ remit was broad: to advise designers and operating staff on how to avoid accidents, specifically with regards to process accidents (rather than slips, trips and falls and so on). Kletz says: “it was a challenge I met through persuasion – by showing them the consequences of bad practices and design, sharing the lessons of accidents and near misses.”

learning lessons

Kletz’ biggest challenge was to ensure such lessons were not forgotten – indeed this would become a mantra for the rest of his career. He wrote in his autobiography: “It is not sufficient to check that rules are being followed or people will stop following them as soon as attention decreases. We have to convince people they *should* be followed.”

Kletz used weekly briefings, where he challenged representatives from key departments to an open group discussion of an incident, to get people to actively think about safety issues.

Kletz points out that sadly, nearly every accident that happens has happened before. “Following an accident, I used to say to people who’ve had an accident ‘don’t write a report, I’ve got it on file already,’” he says.

safety newsletters

To better share information, Kletz started compiling that kind of information in a series of safety newsletters, which were read by plant managers, designers, and maintenance people throughout ICI and at many companies beyond. It was a runaway success: while the first issue in 1968 was sent to only around 30 people, by the time Kletz left ICI in 1982 it was circulated to several thousand people in all of ICI’s divisions and many external companies, university and safety regulators.

Kletz was also a strong supporter of IChemE’s *Loss Prevention Bulletin*, a



bi-monthly magazine sharing lessons from incidents.

don't ask, just do

Like most things he did, Kletz grasped the initiative without seeking permission or approval from superiors – not for starting the newsletter, nor for setting numerical safety targets, or indeed whether a particular type of equipment should be installed at a given facility.

“This was typical for ICI’s ethos – you didn’t ask what you should do, you just did what you thought was right,” he says. In his autobiography, he adds: “If one asked permission there was a 50% chance it would be refused. If one just got on with it, 19 times out of 20 nothing was said.” Even if there was the odd manager that had reservations, Kletz maintains it was far better to explain what he had done, than what he was going to do.

inherent safety

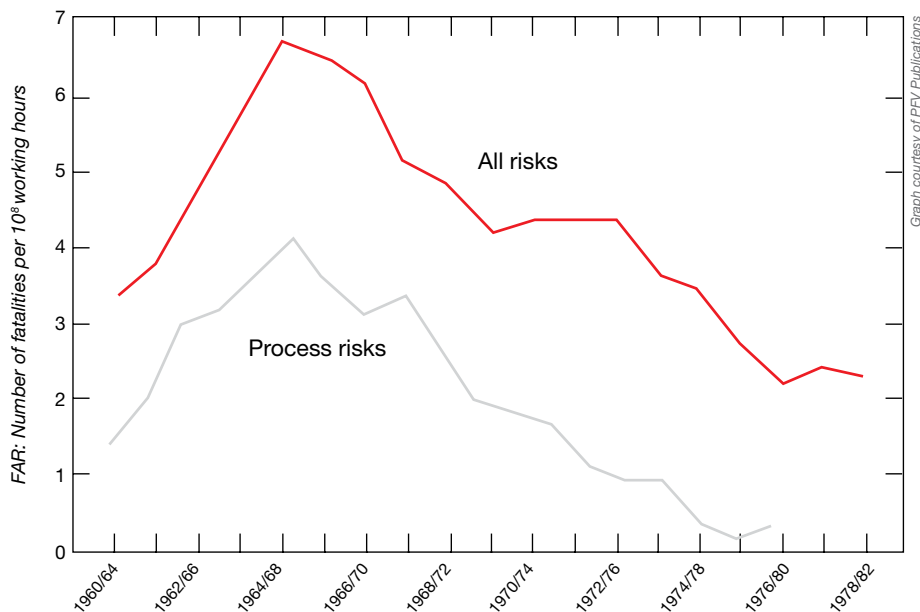
The plethora of accidents and near misses that Kletz examined in his role as safety advisor germinated what would become his fundamental insight: the idea of inherent safety, summed up neatly in his 1978 article “What you Don’t Have, Can’t Leak.”

The article was prompted by the Flixborough explosion four years earlier, the UK’s worst ever chemicals accident. Kletz, who contributed to a government enquiry considering the wider implications of Flixborough, noted that the explosion at Flixborough was so devastating because the process was very inefficient, and the plant ran with a large inventory of hazardous chemicals. The best way to make the plant safer would be to increase the conversion rate and reduce the inventory, Kletz argued.

In developing the idea further in his book *Process Plants: A Handbook for Inherently Safer Design*, Kletz identified four principles:

Intensification: Use small amounts of hazardous materials (a smaller inventory) so the consequences of accidents arising from the escape of materials are much reduced.

Substitution: Use a less hazardous material – less flammable or less toxic.



ICI's fatal accident rates (FAR – the number of fatal accidents in 10⁸ working hours or in a group of 1,000 men in a working lifetime) expressed as a 5-year moving average

Attenuation: If a hazardous material must be used, use it a) under less hazardous conditions or b) in the least hazardous form.

Limitation of effects: Limit the effects of failures by changing the design or conditions of use rather than by adding protective equipment that may fail or be neglected.

obvious in hindsight

“Inherent safety is an excellent example of Kletz’ ability to present complex ideas in a simple and understandable way,” says Robin Turney, safety consultant and former longstanding chair of IChemE’s Loss Prevention Panel. “The importance of material hazards, inventory and operating conditions etc were understood beforehand but there was no concept bringing these together. Inherent safety seems obvious now but very few of us were able to see this beforehand.”

Kletz notes that most plant designers were confident in their ability to control hazards and had not given much thought to minimising inventories. That confidence

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Happy birthday Trevor Kletz!

Inherent process safety: building on Kletz’ legacy – PSEP special issue

See www.icheme.org/journals, or for order information email g.hull@elsevier.com, quoting “Trevor Kletz anniversary”



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evaporated in the aftermath of Flixborough and particularly Bhopal – the notorious explosion of a Union Carbide pesticides plant in 1984, which killed 2,000 people.

While the concept was well received within the process engineering community, it still took some time before it became widely applied. Indeed some organisations were too self-absorbed and overconfident to take note of new ideas – notably Union Carbide. Bhopal would not have been anywhere near as deadly had the plant been designed to Kletz' ideal. "Afterwards Union Carbide (and other companies) greatly reduced their storage capacity for MIC and other toxic intermediates," Kletz wrote. But despite the fact that the ideas had been discussed for almost ten years already, Kletz says he doubts if those concerned at Union Carbide had ever heard of the phrase "what you don't have can't leak", or the concept of inherently safer plants, which springs from it. It is devastating that it took such a huge loss of life to shatter the complacent reliance on safety systems.

lasting legacy

The numbers speak for themselves: during Kletz' 14 years as safety advisor to ICI, the company's fatal accident rate fell from seven fatalities per 10⁸ working hours (four of which were from process risks) in 1968 to 2.5 fatalities per 10⁸ working hours (with almost none from process risks) at the time of his retirement in 1982.

In broader industry, the impact of his work is impossible to chart, and nobody can count how many lives he has saved. Clearly, neither Flixborough nor Bhopal would have been anything near as deadly as they were had the plants in question been designed according to Kletz' tenets – and with his thinking enshrined in today's safety legislation, there is no question that Kletz is one chemical engineer who changed the world.

a lasting legacy

Summing up Kletz' legacy is not easy, because he has contributed in many different ways. Turney says: "Before Flixborough, there was an emphasis on conventional safety and 'following the rules.' These rules, which were

based on past experience, were effective for many of the conventional hazards, they were not good enough for a chemical industry which was facing rapid change, with new processes and dramatic increases in scale. Trevor's main contribution was to recognise that a different, risk-based approach was necessary to control these hazards."

He adds: "In my mind, Trevor's greatest contribution has been to give process safety a respectability and interest which enabled engineers across the world to adopt it and apply it to the plants for which they were responsible."

Judith Hackitt, chair of the Health and Safety Executive and deputy president of IChemE, says: "Many of the tough messages which I now deliver to the UK's major hazard industries as chair of HSE are designed to reinforce the principles and lessons that I have learned from Trevor. His messages about the importance of inherent safety in design and the need to learn and share lessons from incidents are as true today as they have ever been and the need to pass the message on to future generations of engineers will never stop."

For himself, speaking just ahead of his 90th birthday, Kletz simply says: "I've saved a lot of people's lives. That's something I can be proud of."

further reading

The most recent issue of our journal *Process Safety and Environmental Protection* is a special issue in honour of Kletz' 90th birthday, and a special issue of the *Loss Prevention Bulletin* charting his contribution to process safety is due out in early October.

Meanwhile, an archive of Kletz' ICI Safety Newsletters is available for free via IChemE's website: visit www.icheme.org/shop and search for 'newsletter'.

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