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Searchlights from the past☆

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Abstract

"Modern man", wrote the historian, E.H. Carr, "peers eagerly back into the twilight from which he has come, in the hope that its faint beams will illuminate the obscurity into which he is going . . .". Carr is wrong. For those who are willing to look, searchlights, not faint beams, shine out from the past and show us the pits into which we will fall if we do not look where we are going. Some of these searchlights illuminate specific technical risks while others remind us of general principles. In an age of rapid change people are particularly prone to ignore the past, but while technology changes, people do not.

Keywords: Accidents; Information retrieval; Investigations; Learning from the past; Process safety; Safety

"Modern man", wrote, E.H. Carr, "peers eagerly back into the twilight from which he has come, in the hope that its faint beams will illuminate the obscurity into which he is going. He was an historian not a technologist and perhaps to him the beams seemed faint. But to those concerned with industrial safety and other technical problems the light from the past is more like a searchlight than a faint beam. If we ignore it we do so by choice. However, it has become the custom and practice in many companies and plants.

1. An old monthly report

The following is an extract from a chemical company's monthly S*afety Newsletter* from 1972, pulled out at random from a collection of them covering the years 1968–1983. As you will see, every incident in it could happen today and the advice in it is still relevant. But I shall be surprised if anyone working in the company today, or in the many plants which the company owned in 1972 but has since sold, has seen it or has access to it. Perhaps a few squirrels will have kept copies.

Remember as you read the following that there may now be better solutions to the problems than those described, but the incidents could still happen. If they could happen on your plant what have you done or should you do to prevent them happening? I have added a few notes on the wider lessons to be learnt.

1.1. A fire in an empty floating roof tank

The roof of a floating roof tank had to be replaced. The tank was emptied, purged with nitrogen and steamed for 6 days. Each of the float chambers was steamed for 4 h. Rust and sludge were removed from the tank. Demolition then started.

Fourteen days later a small fire occurred. About a gallon of gasoline came out of one of the hollow legs which supported the roof when it was off float, and was ignited by a spark. The fire was put out with dry powder. It was believed that the bottom of the hollow leg was blocked with sludge and that as cutting took place near the leg it moved and disturbed the sludge (Fig. 1).

Before welding or burning is permitted on floating roof tanks, the legs should be flushed with water from the top. On some tanks the bottoms of the legs are sealed. Holes should be drilled in them so that they can be flushed through.

Please do not ignore this incident because there are no floating roof tanks or tanks of any sort in your plant. The lesson we should all draw from it is that we should be on the lookout for places where liquids or solids may be trapped or left behind when equipment is emptied. For example, if a drain line is an inch or

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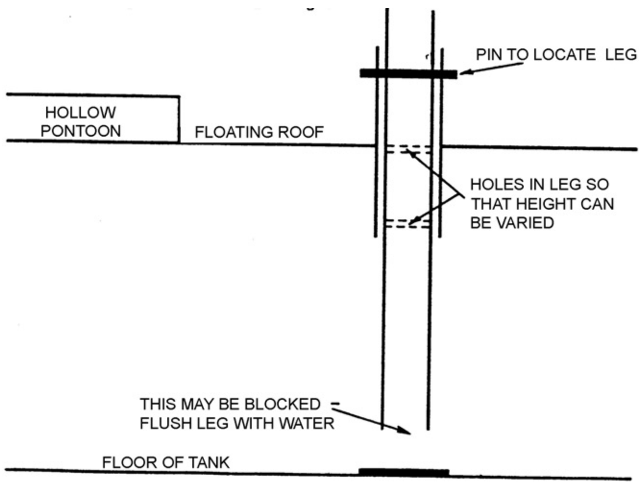

Fig. 1. When a floating roof tank is empty the roof is supported by legs like the one shown. They can be blocked with sludge.

two above the lowest point some liquid will be left behind when the equipment is drained. Unfortunately, when some people read an accident report they do not look for the wider lessons but look only for reasons why a similar accident could not occur on their plant.

1.2. Do not obstruct vent outlets

A vessel was fitted with an explosion vent. The vent was fitted with a hood to protect it from the weather and a baffle to protect anyone who happened to be standing near it when it went off. The result of all this protection was that the area available for flow was less than the area of the vent and in addition the vented gases had to go round some corners. This could have resulted in over-pressuring the vessel. Vent outlets should not be obstructed.

1.3. A tank explodes

An incident in another company shows what can happen if a tank is opened up before it has been gas freed. A bottom man-hole cover was removed from a tank which was empty but still full of gasoline vapor. Vapor came out of the man-hole and caught fire. As the vapor burned, air was sucked into the tank through the vent until the contents became explosive and the tank blew up (from *The Bulletin, The Journal of the (UK) Society for Petroleum Acts Administration*, October 1970, page 68).

1.4. A lift truck hits a valve and destroys a plant

On several occasions recently lift trucks (known as fork lift trucks in the UK) have collided with plant equipment and caused minor damage. *Fire Prevention*, July 1971, page 43, describes a fire which started when a lift truck hit a valve on a crude oil distillation plant. This caused a leak of hot oil which caught fire. Other joints started to leak and the fire spread. In the end the whole unit was destroyed. We should inspect the routes used by our lift trucks and other vehicles, to see if there are any places where they could cause serious leaks of flammable, toxic or corrosive materials.

1.5. More on oil spillages

The same issue of *Fire Prevention* describes a number of fires which occurred after oil had been spilt on water. It can spread a long way. Several men in a rowing boat were killed when oil spilt half a mile away was ignited.

The magazine also describes several instances in which gasoline was spilt and disappeared but came to the surface several years later after heavy rainfall. Do you have any permeable ground rather than concrete in areas where hazardous materials might be spilt?

1.6. Aluminum cladding for insulation

Insulation on pipes and vessels has to be provided with weather protection. In non-corrosive atmospheres galvanized iron sheet can be used but it is not suitable for use on our site and aluminum sheet is used instead. The aluminum is secured with stainless steel bands; self-tapping screws are not satisfactory. Though a fire will destroy the aluminum, the stainless steel bands keep the insulation in place and prevent flaming fragments of aluminum falling off.

Sometimes a moisture-proof paper is attached to the aluminum. On several occasions, including a recent incident in another company, the paper has encouraged the spread of fire. Aluminum sheet should not be used with a paper backing. Other types of moisture protection such as a chromate primer should be used instead.

1.7. From our issue of 3 Years ago [that is, from the same month in 1969]

Another company has now described another explosion in a centrifuge which resulted from the failure of the nitrogen blanketing. There was no alarm system on the supply and no regular analysis for oxygen content. There was no clearly visible indication of the flow of nitrogen. Ignition was caused by the friction between parts of the machine. The report on the incident recommends that:

- The oxygen content of the gas within the centrifuge should be continuously monitored or regular checks should be made using portable equipment.
- The purge nitrogen system should be modified to give a clearly visible indication of the flow to the machines.

Perhaps the incident does not interest you as there are no centrifuges on your plant. What about other equipment which should be blanketed with nitrogen, such as flare stacks, vent stacks and storage tanks? Are you sure the blanketing is operating correctly? Is the oxygen content checked regularly? When did you last see the figures? Is there a flowmeter on the nitrogen line so that the flow can be checked? Do you know what flow is necessary?

1.8. Do we learn from other organizations' experience?

In 1965 two Handley Page Herald airliners crashed with the loss of 116 lives. The cause was found to be "extensive internal skin corrosion", so that the skin ruptured when the plane reached a high altitude. Following these incidents all airliners of this type were thoroughly inspected to make sure that corrosion had not occurred.

These incidents might have provided a general warning of the need to look regularly for hidden corrosion. However; they were considered as something peculiar to Heralds and of little interest to the operators of other aircraft. In 1971, a Vanguard crashed with the loss of 63 lives. The cause was corrosion of the bulkhead, a part of the plane that is difficult to inspect (From the [London] *Sunday Times* for 12 December 1971). *Has it got a message for us?*

When an accident occurs we usually take steps on the plant concerned to make sure it cannot happen again. But on other plants, are we always so thorough? For example, what about the incident described in the last item above? On the plant concerned they have modified their centrifuges. Have you checked yours?

1.9. Often overheard on the plant

"Someone wrote a note on this a couple of years ago but I cannot remember who it was." "This came up last year. There's a report in the file on what we decided to do but I cannot find it." How often have we said something like this? For this reason the Safety Group has been trying to summarize and index their recommendations so that they are readily accessible. The summaries are called Loss Prevention Guides. Twelve had been issued so far and more were in preparation. Here are notes on three of them.

From Guide No. 1, Relief Valves: Exclusion of Air: Flammable mixtures of gases or vapors with air should not be permitted in vent or flare stacks. To this end all-welded construction should be employed and joints should only be made between machined surfaces. Maintenance on live systems should be carried out in such a way that ingress of air is avoided and the system should be purged with inert gas.

Oxygen monitoring should be carried out continuously on big stacks, at least daily on smaller ones. In the presence of hydrogen the oxygen content should not exceed 5% (preferably 4%). For hydrocarbons in the absence of hydrogen, up to 10% oxygen is permissible but a target of 5% should be set. When hydrogen is present the minimum velocity in the stack should be 0.25 ft/s; for hydrocarbons heavier than air it should be 0.1–0.2 ft/s. Inert or fuel gas should be used to maintain these rates and concentrations. Flowmeters should be used on these gas streams in preference to flow indicators.

From Guide No. 9, Thermal Radiation: Permitted Radiation Levels: The currently permitted radiation levels in the company are:

- 1.7 kw/m^2 (500 $BTU/h/ft^2$) for exposure of the general public or for continuous working.
- 5 kw/m^2 (1500 $BTU/h/ft^2$) for short time exposure of personnel.
- 13 kw/m^2 (4000 $BTU/h/ft^2$) for control room externals.

From Guide No. 12, Electrical Area Classification: Pumps: The horizontal extent of the Division 2 Area varies with the volatility of the material being pumped. For pumps fitted with external throttle bushes, the distance varies from 10 m for naphtha below 100 °C to 30 m for a C3 stream, the vertical height being 1.5 m in both cases [this was followed by a list of all the Loss Prevention Guides].

1.10. What the (UK) law says

(A person) is not of course, bound to anticipate folly in all its forms, but he is not entitled to put out of consideration the teachings of experience as to the form those follies commonly take." A House of Lords judgment quoted in *The Guardian* (London), 7 February 1966.

1.11. An unusual accident

A girl who felt the need of a snack during a break period had a harrowing experience. She had two hard boiled-eggs, already peeled, that she put in a microwave oven for a quick warm-up. They had not been in the oven very long and were not hot to the touch when she bit into one. An explosion ripped the egg apart sending yolk all over the place, but mostly over her face and eyelids. She was also burned on the lips, tongue and cheek.

It was no hand grenade; just an egg. But the microwave oven heated the interior and the hard-boiled egg white was just strong enough to hold it together. Safety people were able to duplicate the egg explosion. Microwave ovens have their merits, but also their problems. Nothing, particularly a can – nor as it seems, even an egg – that has a non-porous casing should be warmed in such an oven (MCA Case History No. 1769, quoted in the *Quarterly Safety Summary* of the British Chemical Industry Safety Council, October–December 1971).

This incident demonstrates on a small scale the effects of exposing equipment to pressures much higher than that it was designed to withstand. When such events occur many operators find it hard to believe that pressure can cause so much damage and assume that there has been a chemical explosion.

The *Safety Newsletter* ended with a list of some recent publications. It was just a few searchlights from the past. I have a complete set of similar monthly reports from this company, which had at the time about 10,000 employees spread across four sites. The accidents described include many from other companies. The first hundred *Newsletters* (1968–1978) will soon be available on the Internet and there are plans to add the later ones (1978–1983).

Are there any similar old reports in your company or do you destroy old safety reports after a few years? If so you are in effect shredding dollars, the cost of acquiring the information the accidents taught you. If you keep old reports does anyone ever look at them and extract the wisdom in them? Do you ask colleagues who are about to retire what they have got gathering dust in their cupboards?.

2. How can we encourage people to look at the problems lit up by the searchlights?

I list below some of the actions we could take. However, the biggest hurdle to overcome is getting people to accept that there is a problem. Engineers are good at solving problems. We are less good at realizing that there is a problem. In the UK the Health and Safety Executive have issued Improvement Notices to some companies instructing them to set up a system for learning from experience but some of the resulting systems are bureaucratic and ineffective. I suggest the following as necessary features of a good system for preventing the same accidents recurring so often.

Eleven actions that will make you a better chemical engineer:

- Include in every instruction, code and standard a note on the reasons for it and accounts of accidents that would not have occurred if the instruction code or standard had been followed.
- Never remove equipment before we know why it was installed. Never abandon a procedure before we know why it was adopted.
- Describe old accidents as well as recent ones, other companies' accidents as well as our own, in safety bulletins and discuss them at safety meetings.
- Follow up at regular intervals to see that the recommendations made after accidents are being followed, in design as well as operations.
- Remember that the first step down the road to an accident occurs when someone turns a blind eye to a missing blind (or other detail).
- Include important accidents of the past in the training of undergraduates and company employees.
- Keep a folder of old accident reports in every control room. It should be compulsory reading for new employees and others should look through it from time to time.
- Read more books, which tell us what is old, as well as magazines that tell us what is new.
- Make sure that employees at all levels have adequate knowledge and experience. This is particularly important when people with long service are retiring and their successors have less experience.
- Do not destroy old accident reports.
- Provide better methods for searching accident databases. See Appendix A.

There is something seriously wrong with our safety education when so many accidents recur so often. Some simple changes could improve it. We should start safety reports and safety meetings by describing accidents and draw the lessons from them, for two reasons. First, accidents grab our attention and make us read on, or sit up and listen, instead of making the lecture or meeting an opportunity for a rest. Second, the accident is the important bit: it tells us what actually happened. We may not agree with the author's recommendations, we may be able to think of better ones, but we would be foolish to ignore the event.

Another weakness with safety training is that it usually consists of talking to people rather than discussing with them. Instead of describing an accident and the recommendations made afterwards, outline the story and let the audience question you to find out the rest of the facts, the facts that *they think* are important and want to know. Then ask the audience to say what *they think* ought to be done to prevent the accidents happening again. More will be remembered and the audience will be more committed than if they were merely told what to do [1].

Once someone has blown up a plant they rarely do so again, at least not in the same way. But when he or she leaves, the successor lacks the experience. Discussing accidents is not as effective as a learning experience as letting them happen but it is the best simulation available and is a lot better than reading a report or listening to a talk. We should choose for discussion accidents that bring out important messages such as the need for permits-to-work, the control of modifications, inherently safer designs and so on. In addition, we should devise better retrieval systems so that we can find, more easily than at present, details of past accidents, in our own and other companies, and the recommendations made afterwards [2].

Undergraduate training should include discussion of some accidents, chosen because they illustrate important safety principles such as the need for inherently safer design, the identification and assessment of hazards, the science of fires and explosions and the need to look below the immediate technical causes for ways of avoiding the hazard and for weaknesses in the management system. Discussion, as already mentioned, is more effective than lecturing but more time-consuming. If universities do not provide this sort of training industry should provide it. In any case, new recruits will need training on the specific hazards of the industry.

3. Constraints to be overcome

An important constraint is the belief that the past is irrelevant. We are probably the first society that does not value experience. Many people feel that technology has changed so much that old experience is worthless. The accidents I have quoted show that this is not the case. Of course, messages from the past cannot tell us everything as new processes and equipment may bring some new problems but while processes and equipment have changed, a more important factor, human nature, has not. Equipment failures were and are human failures though not always by an operator; designers, constructors, maintainers, managers and specifiers can also make errors. Specifiers include senior people who decide which process is used, where the plant is located, whether or not there is time to consider alternative designs and so on. It is nonsense to say that something was an equipment failure rather than a human failure.

According to historian Lowenthal [3] a lack of interest in the past (and future) is typical of our society as a whole. He writes, "In the popular mind, both what was and what will be have shrunk, not in actual length and volume but in how these are grasped and felt. People care about ever briefer time spans: immediacy junks the past and starves the future . . . The past, formerly guide and mentor degenerates . . .". We have a sentimental interest in heritage but do not let information about the past influence our actions.

Another constraint is that everyone has an inclination to forget their blunders and does not want them to be publicized. One of the reasons for the success of the *Newsletters* from which I quoted above is that they were anonymous. The location was not stated unless it was quoted in the title of a published report. Looking up "forgetfulness" in a book of quotations I found that most of those quoted thought it was a good thing, that it made life more bearable. We have all at some time done or said things that we regret and we do not like to be reminded of them but errors that result in injury or damage to plant should not be in that category. We should publicize them.

A third constraint is the rather casual attitude that many senior mangers have to the publication of accident reports. It often depends more on the initiative of more junior people and is often tolerated rather than encouraged by those at the head of the company, who have failed to recognize the need for it. There are four reasons why they should actively encourage it:

1. *Moral*: if we have information which may prevent accidents there is a moral duty to pass it on to other people.
2. *Economic*: some companies spend a lot of money on safety. By telling our competitors what we have done we encourage them to spend as much.
3. *Pragmatic*: we get useful information from other companies in return for the information we have given them.
4. *In the eyes of the public, the chemical industry is one*. The whole industry suffers if one company performs badly. To misquote the well-known words of John Donne:

   No plant is an Island, entire of itself; every plant is a piece of the Continent, a part of the main. Any plant's loss diminishes us, because we are involved in the Industry: and therefore never send to know for whom the inquiry sitteth; it sitteth for thee.

Appendix A. Improving databases

There are many databases of accidents as well as books of case histories but they have been little used. We need better retrieval systems so that we can find, more easily than at present, details of past accidents, in our own and other companies, and the recommendations made afterwards. Three improvements are desirable.

1. We need a program similar to Google that can draw on many databases, books of case histories and other sources. No one has the time to look at many such sources themselves.
2. Searching is hit-or-miss; we either get a "hit" or we do not. A "fuzzy" search engine will offer us reports on compounds, equipment or operations similar to those we are searching for. This is done by arranging the keywords in a sort of family tree. If there are no reports on the keyword, the system will offer reports on its parents or siblings. Work at Loughborough University has demonstrated the feasibility of fuzzy searching [4–7].
3. In conventional searching the computer is passive and the user is active. The user has to ask the database if there is any information on, say, accidents involving particular substances, operations or equipment. The user has to suspect that there may be a hazard or he or she will not look. We need a system in which the user is passive and the computer is active. With such a system, if someone types "X" the computer will signal that the database contains information on this substance, subject or equipment. A click of the mouse will then display the data. As we type the spellcheck and grammar check programs are running in the background of our computers and drawing attention to our spelling and grammar errors. In a similar way, a safety database could draw attention to any subject on which it has data. A program of this type has been developed for medical use. Without the doctor taking any action the program reviews the information on symptoms, treatment, diagnosis, etc. already entered for other purposes and suggests treatments that the doctor may have overlooked or not be aware [8].

Compared with what Google have achieved [9] all that I suggest should be straightforward but we need someone willing to develop the software.

When I retired from industry in 1982 I thought that after 5 years consultancy I would be too out-of-date to continue. It did not happen. Accidents similar to those I was reporting long before 1982 are still recurring.

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