

LOOKING BEYOND ALARP — OVERCOMING ITS LIMITATIONS

Trevor A. Kletz
Department of Chemical Engineering, Loughborough University

The concept of ALARP (that risks should be As Low As Reasonably Practicable) is unique amongst the World's legislations and has served us well. However, in striving to make specific industrial risks ALARP we sometimes increase other risks. For example, after the Flixborough explosion the manufacturing process was replaced by a less hazardous one, using a raw material manufactured elsewhere by an equally hazardous process. Similarly, when extra equipment was proposed to decrease the amount of benzene vapour discharged to plant environments it was alleged that, on average, we could expect more people to be killed constructing the new equipment than would ever be saved by the reduction in the concentration of benzene vapour. Other examples are described.

ALARP has served us well for many years but the time has come to move on and supplement it by considering also whether or not there is a net increase or decrease in safety.

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The 1961 Factories Act introduced into UK statute law the concept that industrial risks should be as low as reasonably practicable (ALARP): if a risk is insignificant in relation to the cost of removing it, in money, time or trouble, then it is not necessary to do so though there must be a gross disproportion between the cost and the risk. The 1961 law legalised what was already the normal practice of the Factories Inspectorate, the predecessor of the Health and Safety Executive (HSE). This way of looking at risks is, I think, unique among the World's legislations, and has served us well. The HSE have said that the availability of the money cannot be taken into account; that is, we cannot tolerate risks just because we do not have, or cannot borrow, the money needed to remove or reduce them. However, according to a judgement quoted by F.B. Wright, ALARP "can involve increased levels of expenditure for more affluent employers"[1].

The position of ALARP under European law is not clear. According to one directive health and safety "should not be subordinated to purely economic considerations" but "Redgrave" quotes a case in which a Court gave precedence to "parliamentary intention"[2].

Quantitative risk assessment (QRA), often called hazard analysis or Hazan in the chemical industry, was a development of ALARP; it made ALARP quantitative, and for this reason it was readily accepted by the Factory Inspectorate and, from its formation in 1974, by HSE.

In the development of QRA single target levels of risk were at first suggested, different for employees and members of the public: if risks were above the targets they should be reduced as matter of priority; if they were lower they should be accepted (we would now say tolerated) at least for the time being. Later HSE proposed two levels of risk: an upper one that should never ("Well, hardly ever") be exceeded, and a lower one below which there was no need to go. In between was the ALARP range where cost-benefit analysis should be used to see if reduction is "reasonably practicable".

This concept was further developed by HSE in the two editions of the *Tolerability of Risk*[3] document, in the 1999 Discussion version *of Reducing Risks*, *Protecting People* (RRPP), and now in the definitive version of RRPP[4]. In all these versions figures are suggested for the levels of risk that are intolerable and those that are broadly acceptable, that is, for the upper and lower limits of the tolerable range, the range in which risks should be reduced if it is reasonably practicable to do so. There are still different upper levels for employees and members of the public.

RRPP is an excellent publication explaining not only HSE's guiding principles and the logic behind them but also explaining how it applies them in practice. It deserves a wide readership, amongst managers as well as safety professionals. The latter should read at least the Section on "Criteria for reaching decisions".

The *Tolerability* reports suggested that for nuclear risks the maximum tolerable risk to a member of the public should be ten times lower than for other industrial risks. In RRPP this suggestion has been removed but HSE are prepared to see more money spent on reducing "risks for which people appear to have high aversion" than they would normally recommend (paragraph 103).

However, they do not say how much more. Ten times more might be defensible on the grounds that some forms of death are more unpleasant than others. But in practice the variation in the sums actually spent is far greater. Very roughly, the Health Service spends up to tens of thousands of pounds to save a life, road engineers spend up to a million or so pounds, the chemical industry spends many millions and the nuclear industry hundreds of millions (at the margin). If we look further afield, children's lives can be saved in the Third World for a few pounds. The HSE say that such diversion of resources is a matter for government, not for them. This is true but HSE could at least point out the discrepancies. As servants of the public HSE rightly try to do what the public wants. This is democracy in action but can easily become giving the most to those who shout the loudest.

However there is a more serious criticism of the ALARP concept. In striving to get specific industrial risks as low as reasonably practicable we may end up increasing the risks to other people. The net safety is decreased. Here are some examples.

FLIXBOROUGH

The worst explosion in the UK chemical industry occurred at Flixborough in 1974; 28 people were killed. The process was a stage in the manufacture of nylon: cyclohexane was oxidised to a mixture of cyclohexanone and cyclohexanol, usually known as KA or ketone/alcohol mixture. When the plant was rebuilt the KA was manufactured by an

alternative route, the hydrogenation of phenol. This was widely quoted as a change to an inherently safer route. However, the phenol has to be manufactured and this is usually done by the oxidation of cumene to its hydroperoxide and its "cleavage" to phenol and acetone. This process is certainly as hazardous, perhaps more hazardous, than the oxidation of cyclohexane[5]. It was not carried out at Flixborough but elsewhere. There was less hazard on the Flixborough site, there had to be or public reaction would have prevented rebuilding, but no reduction, perhaps some increase, in the total hazard. The hazard was merely exported.

The rebuilt plant had a short life. It was closed down after a few years for commercial reasons.

THE TRANSPORT OF HAZARDOUS CHEMICALS

An HSE report[6] compared the risks of transporting chemicals by road and rail. One of the conclusions was that "one cannot say that road is generally safer than rail or vice versa. Much depends on the particular circumstances of each route . . . [T]here is no justification for insisting on a general transfer, on safety grounds, from road to rail." However, the authors of the report were told not to take ordinary road accidents into account. If they had done so, rail would have come out as safer in all, or almost all, cases. I imply no criticism of HSE, only of those who wrote the terms of reference. By refusing to consider the net risk, they were losing an opportunity to reduce road accidents. (See also the Conclusions at the end of this paper.)

In contrast, at one time ICI moved an aqueous solution of an intermediate 200 miles by road for further processing. A proposal was prepared to reduce the cost by 80 percent by transporting a concentrated intermediate instead, but this substance was corrosive. If the road tanker conveying it was involved in an accident and the barrel ruptured then someone might be injured, even killed, by the contents. Some of my colleagues thought that as a responsible company we ought to continue to transport the aqueous solution, as the cost of doing so, though greater, was still "reasonably practicable". One day at about 1 pm I was asked what I thought, as a committee was considering the proposal at 2 pm. I missed my lunch that day but was able to calculate, using average figures for the number of people killed in ordinary road accidents and in accidents involving chemicals, that on average transporting the corrosive concentrate would prevent one death every twelve years from a conventional road accident. (In the UK 3500 people are killed every year on the roads, but an average of less than one in an accident involving the contents of a road tanker carrying chemicals or petrol.) I recommended that we went ahead and transported the concentrated material. This was done, but strictly speaking we did not do all that was reasonably practicable to prevent someone being injured by a spillage during the transport of this concentrated material.

NUCLEAR POWER OR COAL

About twenty years ago I was a member of a sub-committee of the Advisory Committee on the Safety of Nuclear Installations. At one meeting the HSE representative reported a

problem at the reprocessing plant for spent fuel at Sellafield. If the problem was not resolved soon there would be an increased risk to the workforce there which would justify HSE shutting down the plant until the problem was resolved. Nuclear power stations would then have to reduce output, as storage for spent fuel was limited. More coal would have to be burnt. I asked if the increased risk to coalminers was taken into account in the risk calculations. The chairman said that to take this into account would be going too far. However, I think it would have been wrong to increase the risk to coalminers to prevent a smaller increase in risk to nuclear workers, if that was indeed the case. (Fortunately the reprocessing problem was soon resolved.)

BENZENE TOXICITY

Some years ago the US authorities proposed to reduce the threshold limit concentration of benzene, that is, the maximum permitted concentration in a working atmosphere, from 10 ppm to 1 ppm. This was opposed in the courts and withdrawn on the grounds that even if this reduced the risk of death to people exposed by a factor of ten (which was doubtful), more people would be killed constructing the equipment required than would be saved during the life of the plants by reduced exposure to benzene.

INSPECTION OF PIPELINES

Underground pipelines in rural areas are often inspected by helicopter. If any construction or similar activity is seen near the pipeline the helicopter is landed so that the inspector can make sure that the people involved are aware of the pipeline's presence and are following the correct procedures. But how does the risk to the inspectors in the helicopter compare with the risks that they prevent? It was a fair question to ask and calculations showed that the inspections produced a net increase in safety.

CAPITAL COST v. OPERATING COST

Companies have often economised on the capital cost of new plant and later discovered that as a result operating costs, such as maintenance, have been higher and the total lifetime cost has increased. A cynic might say that by the time this is discovered the design engineers have been rewarded, by promotion or bonus, for keeping the capital costs down. Maintenance is not just expensive; it is also the cause of many accidents. According to HSE[7] 30 percent of accidents are maintenance-related. Reference 8 describes a number of them.

As an example of short-sighted costing, from the window of his office an engineer I knew watched a new unit being built. He calculated that the cost of hiring, erecting and dismantling the scaffolding around a distillation column during construction would have paid for a permanent structure and also avoided the need to hire, re-erect and dismantle scaffolding during subsequent maintenance. Erecting and dismantling scaffolding is a hazardous activity. Failure to consider the life cycle of the project increased the hazards as well as the costs.

CHLORINE OR BLEACH?

An example of inherently safer design, often quoted, is the use of sodium hypchlorite (bleach) instead of chlorine for water treatment. However, Overton and King point out that it is not as simple as it seems at first sight. If the bleach is manufactured at a different site than the chlorine, then the chlorine still has to be transported and we should compare the probability and consequences of a leak at the bleach plant with those of a leak at the water treatment plant[9]. This example shows the need to take broad view and not just look at an individual task in isolation.

DRINKING WATER

Until about twenty years ago most people in Bangladesh and some other poor countries drank surface water, which was often contaminated by sewage. Aid agencies told them that that ground water would be safer and the World Bank provided aid to make it available. However, the ground water is contaminated by arsenic, which has short- and long-term toxic effects. According to a recent report the agencies naively assumed that ground water would be better than surface water and carried out no studies or monitoring[10].

HOSPITALS

When the HSE became responsible for safety in all places of work and not just factories the inspectors discovered that the oxygen pipelines in some hospitals were not up to the standard that they would have required in industry. The hospital staff pointed out that the cost of bringing them up to standard would save more lives if spent on the normal work of the hospitals. The HSE did not dispute this or insist on immediate action but said that the existing state could not continue indefinitely. They suggested that the National Health Service should establish separate budgets for improvements to equipment such as oxygen lines. However, this procedural ingenuity hides the dilemma but does not solve it.

RAILWAYS

Railway accidents provide some of the best examples of the failure to consider the net safety outcome of proposed changes. Newspapers demand and politicians promise unlimited expenditure to prevent repeats though the worst railway accidents of recent years have killed no more people than are killed every few days in road accidents. Excessive speed restrictions, long interruptions of service and ignorance of the relative risks drive people onto the roads. The then chief executive of Railway Safety wrote a few year ago[11] that the Health and Safety at Work Act

> "effectively prohibits the HSE from considering wider societal risks within their regulatory decisions; and as we saw after Hatfield the Executive will not do so. These problems . . . lead me to conclude that it is time for specific

> railway legislation to be considered. The legislation should require an assessment of the total safety impact of new measures including modal shift. Only if a net safety benefit is delivered should regulatory action be permitted. This is the sort of debate the politicians should be promoting rather than decrying those who have to apply the existing legislation . . .”

As my examples have shown these remarks apply more widely and not just to the railways. Another writer in the same publication as the quotation[12] suggests that on the railways ALARP has been replaced in practice by ALAPE (As Low as Politically Expedient).

Here is another example of the way in which over-zealous safety applications have resulted in a net decrease in transport safety: At little-used train stations there are no footbridges and passengers are allowed to cross the track. If the service is increased above a certain level of frequency, the HSE requires footbridges to be installed at a cost of several hundred thousand pounds each. According to the Passenger Transport Executives – the bodies responsible for co-ordinating transport in the larger conurbations – this makes an increase in service too costly even though the rolling stock and the paths for it are already available. As result people who might use the trains continue to use their cars. Note that the trains are not express ones, just local ones travelling at much the same speed as heavy road vehicles and slowing down to stop at the stations[13]. In this case HSE seems to have written a standard and then applied it without applying the ALARP principle.

There are other similar examples in the pages of *Modern Railways*[14]. In some of them instead of applying the ALARP principle a standard has been followed uncritically. Many new standards are now being written and ALARP applied[15] but this does not cove the problem discussed in this paper: a change which is too expensive to be ALARP, so far as the railways are concerned, may result in more people travelling by road and a decrease in total safety.

Parliament recognized this problem as far back as 1864 when the Railway Facilities Act allowed railways to be built to lower standards provided axle load were less than 8 tons and speeds less than 25 mph. However, little use was made of this concession, partly because it applied only when the landowner did not object and partly because of the same public demand for super safety that we see today.[16]

In applying ALARP to road improvement schemes the Government is willing to spend £1.2 million (at 2001 prices) to prevent a fatality. (They call it the Value for Preventable Fatalities.) For railways the published value is £2.8 million presumably because it is a “risk for which people appear to have high aversion”. In practise, however, much larger sums have been spent, for example, about £10 million for the installation of the Train Protection and Warning System which will reduce by 70% the incidence of signals passed at danger[17,18]. However, both £1.2 and £2.8 millions are well below the sums, quoted earlier, spent by the chemical, oil and, especially, the nuclear industries to prevent fatalities.

In mid-2004 the Government announced that responsibility for railway safety will be transferred from HSE to the Office of the Rail Regulator. This does not involve any change in the law.

CONCLUSIONS

ALARP has served us well for a long time but it is now time to move on – not to replace it but to supplement it – by considering the also the net safety benefit or detriment. It is arguable that when engineers fail to do so they are breaking the requirements of their professional codes of practice. For example, the Institution of Chemical Engineer's *Rules of Professional Conduct and Disciplinary Regulations*, Issue 3, 7 December 2001, state:

> 3. Members when discharging their professional duties shall act with integrity, in the public interest, and to exercise all reasonable professional skill and care to:
>
> (a) Prevent avoidable damage to health and safety.

It is arguable that the HSE report on road v. rail in the transport of hazardous chemicals, described above, failed to fulfil this requirement, as it ignored by far the largest source of risk.

HSE argue that their job is job is to enforce the law, not change it and also that as servants of the public they should do what the public wants. Accordingly, HSE are prepared to see more money spent on reducing "risks for which people appear to have high aversion" than they would normally recommend (RRPP, paragraph 103). As already stated, this is democracy in action but good servants do not uncritically obey their masters. Like Jeeves in the P.G. Wodehouse stories, they first point out the disadvantages of the master's proposed actions. HSE could do the same.

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