DISCUSSION - SESSION TWO

FLAMMABLE LIQUID STORAGE AND EXPLOSIBILITY OF HYDROCARBON

THE FIRE PROTECTION OF FLAMMABLE LIQUID STORAGES WITH WATER SPRAYS
by P Nash
THE FIRE PROTECTION OF FLAMMABLE LIQUID RISKS BY FOAMS
by J G Corrie

Mr J M Alexander (ICI, Billingham):

Calculation of radiation incident on tanks adjacent to a fire should enable further economies of water consumption to be made, even though 'worst conditions' have been assumed in flame height, radiation flux from the flame, etc.

I would like to reinforce the point made by Mr Corrie about sloping the ground underneath plant handling flammable materials. It is important to break up the slope so that individual plant items and associated equipment slope to a drain rather than onto another plant item.

Mr P Nash:

0.2 gallons per sq ft per minute is a fairly generous figure for normal applications. We have experience of an untreated canvas cover over a lifeboat, totally immersed in flames, remaining unscorched with this degree of water coverage. Economies can be made by taking advantage of water run-off from higher surfaces. For example, in the protection of a storage tank, the top surface and upper part of the sides may need to be given the full figure of 0.2 gal/ft^2 min, whereas the lower parts of the sides could receive less since they will be cooled by water run-off from higher up, will have a more favourable configuration factor and the heat-sink effect of the liquid within the tank.

Mr Corrie:

Configuration factor! I have never seen a real situation in which the shape of the flames conformed with the 'theoretical' shape of one diameter wide, tapering to a point at two diameters high. Usually the flame 'lies over' in the wind, the flames are lost in the dense smoke, and so on. This means that there is a great difference in radiation in the windward and leeward sides. We have a paper coming out in the near future which has a few more measurements on radiation. We have a long way to go before we have an accepted measure of the radiation of large fires which we can use with the utmost confidence to calculate the water we need for cooling.

Mr J M Alexander:

I would like to emphasise the training of plant operators to put out fires for themselves. On our large site at Wilton, plant operators are taken to the fire training ground once a year and given tray fires, running fires and simulated pump seal fires to extinguish. The result has been a significant reduction in the number of fires the site fire brigade has to deal with. Many more minor fires are now extinguished because the operators are better trained. I understood from an earlier Institution of Chemical Engineers Symposium that it was ICI experience that about 95% of industrial fire loss derived from 5% of the fire occurrence, and half of these ought to have been put out by portable (hand) extinguishers anyway but weren't.

Mr P Nash:

I think it is true that expertise always plays a large part in fighting fires with hand equipment. Foam is, however, less subject to operator technique than is powder, simply because foam on a surface gives a certain coverage, a certain degree of progress towards extinguishing the fire. Even if the extinguisher runs out, the foam already applied will 'buy time' for the operator to get a further extinguisher.

Powders are transient in their effect, and the fire must therefore be extinguished completely or it will reflash. This is where an experienced operator may achieve extinction, where the inexperienced one fails to achieve anything.

To offset the transient effect of dry powder to some degree, it should be remembered that weight for weight, dry powder is more effective than foam. For example, an ordinary 2 gallon foam extinguisher will deal with about $30ft^2$ of petrol fire, but a 20lb dry powder extinguisher can deal with about $70-80ft^2$ of petrol fire. The performance of the new fluorinated foams is commensurate with that of dry powder.

Mr Corrie:

Technique is very important because it gives the confidence necessary to achieve the best results. For example, with foam application to a fire, there will be little apparent effect for 15-20 seconds, but the fire will then subside rapidly. An experienced man will know this and will not be put off. He will also know that it is important to get into action quickly, before everything in the vicinity becomes too hot.

Dr Hutton (Laporte Industrion Ltd):

There is a requirement on chemical plant for sloping floors to drain organic material away from plant. On application of foam to such areas, this will drain out of the region into the drain rather than cover the plant area. Could Mr Corrie comment on the maximum slope permissible or any alternative methods of tackling this problem? Also comment on the effectiveness of foam sprinkler and foam pouring systems.

Mr Corrie:

We have done no work with foam sprinklers for a long time, but there is a place for these in the protection of plant complexes. They have been shown to be effective in areas such as boiler houses, etc, where flammable liquid spillages or drainage may occur, amongst a lot of hot metal surfaces and pipework.

The sloping floor question is difficult, as foam does drain its liquid and tends to float downhill on the liquid. Usually, however, it forms a layer at the base of a slope, or wherever a lodgement can occur, and builds up from there as further foam arrives. The residual liquid then drains away beneath the layer without causing further movement. In some recent tests at London Airport, this was observed to happen in the early stages, and the foam then built up a satisfactory layer which took a long time to break down.

Mr M Kneale (Lankro Chemicals Ltd):

During the Safety Research Seminar held on the 8th April the question of bunding for liquefied gases had been discussed, and it had been asserted that it was pointless to put such tanks in bunds above the ground level as any spillage would immediately flash off. If such tanks were to be bunded it was suggested that they should be completely below ground level. A picture of the water spray system, however, showed liquefied gas storage tanks in low level bunds above ground levels. What are the authors' views? Is there not an advantage in building fire walls between the tanks?

Mr P Nash:

I was merely showing the water spray system as a means of protecting tanks from radiated heat. With a fire wall in between each tank, this is bound to give further protection, provided it does not interfere with the water distribution from the sprays. The wall will itself be kept cool by the spray falling upon it. The method could not be used, of course, with very large tanks.

Mr Corrie:

Where there is a number of small tanks in one bund, further sub-division of the bund with dwarf walls might be an effective method of containing a spillage to an even smaller area. Even one brick high could make a difference.

Mr J Stirzaker (ICI, Blackley):

A well known hazardous operation is that of flame cutting and/ or welding of storage tanks which have held flammable liquids. I would like to ask Mr Corrie's views on the use of inert gas foams in this respect.

Mr Corrie:

We are planning and hope to do some experimental work in the near future. We have thought quite a lot about it and about using air foam or inert foam but air foam could have limitations in a tank which had oil deposits on its sides. We think inert foam certainly seems a very promising answer but there are problems to know whether a certain tank is full of foam and all too easily you could get pockets of air trapped in the tank and this is what we hope to investigate.

THE EVAPORATION AND DISPERSION OF FLAMMABLE LIQUID SPILLAGES by V J Clancey

Mr J M Alexander (ICI, Billingham):

We are fairly confident from local meteorological information of wind speed and direction at any point. For normal conditions one can calculate with reasonable certainty what is going to happen in analysing the spread of a flammable or toxic vapour. Conditions of inversion vary considerably from one locality to another so how do we bring inversion into our analysis?

In the assumption of normal Gaussian distribution in the composition of a flammable cloud we must remember that if the leak is a high velocity jet with sufficient momentum to entrain and mix air to give a stoichometric mixture and the wind is light, then a very large homogenous cloud of flammable vapour may form. This cloud could well be capable of very fast deflagration or even detonation. Would Mr Clancey care to comment?

Mr Clancey:

Generation of vapour is presenting a very difficult problem. In many cases there are going to be momentum effects and we have ignored them. The only excuse is that we do not know how to deal with them and by ignoring them one is postulating a cloud which is going to transfer further than one would if it were already mixed from source. The problem of momentum jets has been dealt with very adequately by Long, but if one is considering momentum jets from the failure of a flange, we have no data at all. This would benefit from some study.

I have included some data in the paper. Coefficient C and the constant N are given different values for inversion and these have been tested out to some extent by large-scale measurements and are reasonably accurate. These calculations for concentrations must be regarded as being in error by a factor of two or three and within that sort of error I think the values given to C and N in this equation do give reasonable values of inversion conditions providing one has not got a gravitational effect. We know from experience that a heavy vapour in still air will go enormous distances, but we have no data at all.

Dr H J Pasman (Technological Laboratory, TNO, Rijswijk):

A test series has recently been conducted with freon at a plant near Rotterdam. These tests are interpreted and fitted in a heavy vapour dispersion model set up by the Meteorological Laboratory in Holland. This model will be published at the Loss Prevention Symposium in The Hague next May.

Mr G Trimm (Conoco Ltd, Humber Refinery):

Should LPG tanks really have high bund walls around them? How can LPG vapour be dispersed from a tunnel?

Dr H S Eisner (DTI Safety in Mines Research Establishment):

You can clear a tunnel of vapour by purging it with high expansion foam blown with air or inert gas.

Mr Bulloch (ICI, Mond Division):

Our experience of spillage of liquefied gases suggests that more than the theoretical proportion of liquid 'flashes' effectively instantaneously. This is because as the liquefied gas container depressurises, liquid droplets are flung around and evaporate within seconds of touching the ground. Thus, although theoretically roughly 20% of liquefied chlorine would flash on a spillage, in practice our experience suggests that the effective 'flash' can be in excess of 50%. Would Mr Clancey comment?

In a paper by Burgess dealing with the spillage of liquefied chlorine on water, instantaneous concentrations were measured downwind which exceeded Sutton's time average values by a factor of 20. The factor suggested in the paper is 1.7. Would a more realistic factor not lie somewhere between these two values?

Mr Clancey:

It is quite correct that if a spray is produced the amount evaporating is greater than that calculated on the heat balance. Droplets evaporate additionally by acquiring heat from the air. Because of the low specific heat of air compared with the latent heat of vapourisation the amount is very small and may be neglected. Droplets reaching the ground will indeed acquire heat from the ground and consequently tend to evaporate as will the mass of the liquid. The amount will depend upon the boiling point of the liquid compared with ground temperature. The rate will be slower than the original flash-off. Hence in many cases these effects do not contribute significantly to the concentration within the original cloud.

The general opinion, based upon a limited number of observations, is that a practical factor for instantaneous concentrations is probably between 1.7 and 2.3. Burgess's observation has not been confirmed under other conditions. It may well be that these are small volumes of abnormally high concentration but to maintain an average they must be so separated from each other that flame propagation is unlikely.

Mr R L Hunter (ICI, Billingham):

I would like to support Mr Bulloch, ICI, Mond Division, who quoted high flash levels for liquid chlorine releases. Experiments we have carried out with liquid ammonia show that releases of liquid at pressure can produce flash (including aerosol droplets) up to 80% of the liquid released. World incidents of ammonia spillage confirm this.

Mr Clancey:

There was an incident recently in South Africa when liquid ammonia was released which suggested a high vapour production. We need more data on droplet formation and evaporation.

Dr D W Napier (Imperial College):

Have you any information on dispersion of heavy vapours from spillages between buildings?

What is the significance in this context of the meteorologist's term 'wash-out time'?

Mr Clancey:

There is very little data on the dispersion of heavy vapours when there is a gravitational effect. This is a field which is in urgent need of experimental studies.

Mr G Taylor (Greater London Council Scientific Branch):

What is the density of vapour which is to be considered light with respect to the statement on pages 86/87? In other words, when can one use the approach suggested?

Mr Clancey:

As I have just said we lack sufficient experimental data. In the experiment recently carried out in Holland about a ton of Freon 12 of density 4.2 was released instantaneously. At a distance of 1000 m the height of the cloud was about one fifth of that predicted by the Sutton equation, whilst its horizontal diameter was twice. Thus the volume was about the same. Hence the area of ground swept by the cloud was larger. On the assumption that the horizontal distribution of concentration is Gaussian the hazard area could be worked out. For practical purposes, because so many uncertainties exist, probably no great error would be introduced if the treatment were used for densities up to say 1.5 unless there were special topographical or still-air conditions.