Fire Precautions			
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CONTROLLING FIRES IN AGRO-CHEMICAL (PESTICIDES) WAREHOUSES

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Summary

Many of the most toxic agro-chemicals in common use are formulated for final sale in flammable solvents. Organophosphorus pesticides are an important example, these are typically sold in 1 to 5 litre containers, as solutions in xylene. The containers are usually high density polyethylene (HDPE); these have good resistance to breakage in transit but they are rapidly breached in a fire. Pesticides are usually further packaged in cardboard boxes and shrink wrapped on pallets with 500-1000 kg per pallet. An agro-chemicals warehouse may contain a large number of such pallets together with other types of agro-chemicals. Pallets may be stored singularly at ground level, but more typically because of space constraints, they will often be stacked in racked storage.

A large fire in such a warehouse not only causes the usual damage to stock and property but can threaten both people on site and those living downwind of the fire who may be exposed to smoke containing significant amounts of unburned toxic materials. Deposition of particulates contaminated with pesticide may affect the use of crops grown in farmland and gardens surrounding the site of the fire. Large quantities of contaminated water are also usually produced during efforts to control large fires of this sort. This firewater run-off can cause severe environmental damage. An important example of this was the fire at a Sandoz pesticide warehouse in Basle (1986) which largely wiped out the flora and fauna in the Rhine in a reach of several hundred miles.

Fire tests

Automatic fire suppression systems are a widely used means to reduce the risk of such damaging fires. **There are however few test results to validate the sprinkler design codes used for formulated pesticides** and HSL is currently engaged on a programme of large scale testing to identify the level of risk reduction afforded by various types of system.

Most of the tests to date have involved a single pallet load at ground level. This clearly represents a minimum level of challenge which any suppression system must meet to provide significant risk reduction.

The single pallet load comprised 432 one litre HDPE bottles of xylene in cardboard boxed lots of twelve. The entire load wrapped in polythene. The tests were carried out in a large scale fire test rig (7m cube) at the Health and Safety Laboratory, Buxton.

Fires are started with a small wooden ignition crib. The burning rate increases very rapidly as the first xylene starts to spill from breached bottles. The roof of the rig is fitted with the automatic sprinkler system under test. The number and spacing of sprinkler heads is adjusted to produce the required delivery rate of water or foam solution. Tests to date have used conventional 68 ^{o}C sprinkler heads with a head pressure of 3 bar.

At a rate of 8 litre/min/m^2 of the floor area, the fire is not controlled. The fire size rapidly exceeds 10 MW, melting the polythene sides of the rig, with flames impinging on the underside of the roof of the rig. Coupled with this copious amounts of smoke is produced, smoke logging the rig. Target boxes of bottles placed at ground level at a distance of 3 metres from the ignited pallet were all completely destroyed in the fire. It may therefore be reasonably concluded that this level of water supply would be unlikely to prevent the rapid escalation of fire in a pesticide warehouse.

Increasing the density of sprinklers to provide a water supply of 16 litres/min/m^2 improves control of the fire. In this case a limited pool fire extending about 3 metres from the ignited pallet in the direction of water drainage continued for an extended period. This kind of system would significantly reduce the rate of fire spread, but fire would still be expected to spread at low level to adjacent pallets. After about 12 minutes the water supply to the sprinklers was cut to assess the recovery rate of the fire: **this was extremely rapid.** After a break of 75 seconds the sprinkler supply was re-established at a density of 16 litres/min/m^2 but control of the fire could not be regained. Any interruption of sprinkler supply in this kind of commodity, for example to assist fire brigade operations, runs a high risk of loss of control.

A third test using 16 litres/min/m^2 of 3% AFFF foam showed greatly improved control. The foam blanket rapidly extinguished the pool fire around the pallet, but although well contained, the fire in the pallet load was not fully extinguished. A system of this kind would substantially reduce the risk of any fire spread in a pesticide store with pallets at ground level.

Fires in high rack stores will present a much greater challenge to foam systems because of the increased area available for a running fire on the pallet surface and because of dripping and splashing of fuel from upper pallets disrupts the foam coverage around the base of the stack.

Repeated tests with three single pallet loads, vertically stacked in a rack were carried out. Whereas previously a sprinkler rate of 16 litres/min/m^2 had limited the extent of the pool fire with a single pallet load, with the racked pallets no control of the fire was achieved. The effectiveness of the 16 litres/min/m^2 of 3% AFFF sprinkler rate in controlling the fire involving racked pallets was also much reduced compared to that achieved with the single pallet. The loads on the pallets continuing to burn freely, though the extent of the pool fire was limited.

British Standards

It is interesting to compare the levels of water supply used in these tests and the degree of fire control achieved with the recommendations of the British Standard for sprinkler systems BS 5306: Part 2 (1990). A single pallet load of flammable pesticide could be described as "flammable liquids in combustible containers" i.e. a storage hazard category III commodity, in a free standing stack less than 2.1 metres high. For such a storage a minimum design density of 5 litres/min/m^2 of storage floor area is recommended.

HSL's tests to date using a sprinkler water delivery rate well in excess of this, would indicate that such sprinkler systems designed and installed to this requirement of BS 5306: Part 2 are unlikely to be capable of checking the development of fires involving flammable solvent based agro-chemicals.

Such agro-chemicals would therefore seem to be more appropriately designated in BS 5306: Part 2 as a "special oil or flammable liquid hazard"; ie *"occupancies where oil and flammable*

*liquids are stored or used in such quantities and in such a manner that standard sprinkler protection may **not** be effective."*

Whilst the standard does note that water deluge systems may be effective against these hazards, the levels of water delivery rate required are not specified. However given the results of the tests carried out at HSL, in the absence of evidence to the contrary, the assumption must be that water deluge systems alone will not adequately control fires involving stacked commodities of flammable solvent based agro-chemicals.

Only automatic fire suppression systems employing fire fighting foam would seem capable of achieving any noticeable effect in controlling fire growth. Even with such systems, their effectiveness remains at best debatable, where it is to be noted that the discharge rate of 16 litres/min/$m^2$of 3% AFFF used in the HSL tests is well above the application rate typically found in a commercial system

It may be that the presence of a foam fed automatic sprinkler system in an agro-chemical warehouse might sufficiently retard the fire's development to enable the fire brigade upon their arrival to have a chance of controlling the fire. However this remains unsubstantiated. In particular it is important that the problems the degree of smoke logging, which will generally be very heavy because of the fuels involved and the effects of the sprinkler system will cause fire-fighters in locating and tackling ignited pallets, is not underestimated.

Action

Effect on Assessments

FIREPEST evaluations for land use planning and CIMAH purposes sometimes have to take into account the effectiveness of sprinkler systems to control a fire. For agro-chemicals which are formulated in flammable liquids care has to be exercised when evaluating the effectiveness of sprinkler systems or when claims are made about their effectiveness. If in doubt contact the topic specialist and for further information on this work or the large scale facilities available for commercial fire testing at the Health and Safety Laboratory, contact: Dr Graham Atkinson, Fire Safety Section, Health and Safety Laboratory, Harpur Hill, Buxton SK17 9JN. Tel: 0114 289 2043 Fax: 0114 289 2045

Further Work

It is recognised that the findings of this work are likely to have significant repercussions within the "fire community" (Insurance companies, fire brigades, sprinkler manufacturers etc.) for operational standards. These are currently being explored with the intention of developing guidelines for sprinkler system design. Future progress on this will be reported on by Ian Buckland DST E5; DST having been joint sponsor of this work.

References

An article on the initial findings of this work has been published in the Fire Prevention Journal 305 (December 1997). Cautionary comment on the efficacy of automatic sprinkler systems is also to be made in the revised edition of HS(G) 71 "Chemical Warehousing: Storage of packaged dangerous goods", which is to be published shortly.