SESSION 6A

DEVELOPMENTS IN PACKAGING, HANDLING AND DISPOSAL OF PESTICIDES

CHAIRMAN MR J. SUMMERSCALES

SESSION ORGANISER MR T. H. ROBINSON

PACKAGING LEGISLATION - AN EVER CHANGING SCENE

RAY WHITE

Pira International, Randalls Road, Leatherhead, Surrey KT22 7RU

ABSTRACT

Pressure from green activists and an apparent shortage of landfill sites has focused politicians and bureaucrats' thoughts on the problems of waste management. Packaging has been highlighted because of its high profile with the result that most developed countries are now introducing legislation which limits its use and requires recycling or reuse. One of the key documents is the Draft European Commission Directive published in April 1991 on packaging and its disposal and a second legislative move is the German Laws which are now becoming effective. The paper will discuss the general implications of the legislation and then look at the implications as far as agrochemicals are concerned. It will access the possible changes to current packaging practice and underline the necessity for product stewardship to be extended to used packaging and its safe disposal.

INTRODUCTION

During a recent discussion on the packaging of pesticides with a contact within the industry we found that we had different interpretations of the German packaging/environment legislation. My translation implied that pesticide packaging is included whereas the other translation implied that it is not. If this second view is correct then it could have sinister connotations in that the German Government would no doubt introduce more stringent controls at some future date. No doubt the situation will be resolved well before the end of 1991 when the German legislation is due to become effective, but it also illustrates very well the current situation in Europe which can be summarised in one word - chaos.

We have the German legislation which has been passed by the lower house of Parliament but is subject to 120 amendments from the upper house. Many of these amendments seek to strengthen the legislation and add further restriction such as raising recycling targets to 100% and banning PVC. The French are planning legislation similar to that of Germany but the Dutch (Dutch Packaging Covenant) have gone one stage further and have agreed with industry some very radical measures which, if put into practice, will change the way in which many common household products will be sold. The European Commission has so far this year issued two documents, the second being a Draft Directive (EEC Draft Proposal 1991). Although it was published only six weeks after a discussion paper, many of the original ground rules had been changed in that six week period - and not for the better as far as industry was concerned.

Estimates of waste produced in Europe vary but it is generally agreed that some 2000 million tonnes of solid waste are generated each year. Pira estimates that this is made up of:-

36% industrial waste

59% agricultural waste

5% household waste.

Analysis of household waste shows that it is predominantly paper (newsprint and magazines) and kitchen waste. Packaging is about 35% so, in round figures, packaging represents less than 1.5% of the total waste produced in the European Community so why is it currently the centre of so much controversy and legislation? In Germany, the green pressure groups were actively encouraged by the Government to target packaging rather than the traditional 'hole in the ozone layer' or 'acid rain'. These are, from the politician's point of view, too difficult to tackle without losing popularity.

As packaging is 30% of all household waste it has a high profile in the public's eye, is seen as a waste of good material by throwing it away and therefore an ideal target for legislation by politicians. But laws are written by bureaucrats, often not based on scientific fact which results in perceptions that are very different from reality. The legislation to date has been badly thought through and although it may solve a particular problem it often creates six more. An example of this is the deposit laws on soft drink and beer cans in the States. Introduced to reduce litter they have had the opposite effect. Many people cannot be bothered to claim the deposit and throw the cans away in litter bins. These bins are seen as a source of income by 'down and outs' who just tip the bins out in the sidewalk, take the cans and leave the remaining rubbish to blow away. The most practical alternative appears to be kerbside segregation, where households separate their waste into separate boxes, one for paper, one for plastics, one for batteries, etc. Quite a number of states in America have now abandoned deposit systems and moved over to kerbside segregation although this now has its problems. It is expensive because one is collecting a little material from a wide area. Demand for recycled materials especially plastics is low, and the schemes tend to flood the market so that prices for the waste material drop, making collection uneconomic.

In Europe we are seeing two types of legislation developing - the laws passed by Parliaments and then the gentlemen's agreements which are likely to have a much more dramatic effect on the way in which we run our business. The laws are easy to identify, they are well documented and although perhaps expensive to comply with at least everyone must follow the rules. The gentlemen's agreements are less clear, often not published, but are an arrangement between Government and a sector of industry. For example, not to use a particular material or to change the way a product is sold. This can put an importer at a disadvantage and it is generally more restrictive for industry. The first agreement between industry and government was in Sweden (Swedish Agreement, 1990) where, after pressure from the Green lobby, it was agreed not to use PVC for the packaging of fats from 1 July 1990. Food manufacturers extended this to other food products and it has now begun to affect other products such as cosmetics and more general packaging items such as tapes for corrugated cases where PVC is being replaced with polypropylene. The Dutch Packaging Covenant is far more restrictive and will change the way in which the products are sold and the way in which business is operated. For instance:-

1 Detergent manufacturers have agreed to examine ways of setting up bulk containers in supermarkets so that shoppers can take back their empty bottles and have them refilled.

2 Gift wrapped packs for alcoholic beverages such as brandy and champagne are banned.

3 The packaging industry has agreed to recycle 60% of packaging which cannot be reused - this will require changes in standards and manufacturing processes.

4 Reuse of packaging to be a priority especially for beverages - supermarkets will be required to take back empty bottles.

5 Industry has agreed to reduce the level of new packaging being placed on the market in the year 2000 to the same amount by weight as in 1986 and, if possible, to meet a target of 10% below the 1986 figure.

These examples demonstrate very clearly the impact that these agreements will have on future operations. Whilst these agreements do not have the power of the courts behind them, there is the threat of legal powers being introduced if industry does not conform. It also opens up a possibility within the European Community for States to circumvent the Community Directive on Waste. The Commission has stated that all current packing materials should continue to be used, therefore, for one country to introduce a ban by law on a particular material would be a contravention of the Directive. A gentlemen's agreement not to use it would quite legitimately get round the problem. In Germany, PET is not allowed for beverage containers, not by law, but by coercion from the Ministry of Environment.

Bans on certain types of packaging have been used to protect local industry - beer cans are banned in Denmark on the basis that they are an environmental hazard but, in reality, to protect the beer industry from German imports. The ruling has been challenged in the European Courts but upheld.

In the long run this can only lead to a field day for the lawyers whilst each agreement is tested in the courts. We are also seeing legislation challenged. The German plan which aims to reduce household rubbish by forcing retailers and producers of consumer goods to take back all packaging material is already running into trouble with the German cartel office in Berlin and the EC competition authorities (Financial Times, 1991).

The EC authorities believe the system as currently restructured could offend the Treaty of Rome's free movement of goods and competition clauses. UK and other non-German companies claim the regulations will discriminate against imported goods. But more worrying to the authorities is the company DSD (Duales System Deutschland) which has been set up by more than 500 companies manufacturing and using packaging as well as retailers to run the recycling system. The Government has left it to private industry to organise a collection and recycling scheme to run parallel to the existing household rubbish scheme. Competition authorities fear that the companies who do not join the private scheme run by DSD, which requires all products to carry a green dot showing it has been approved, will be penalised and they would like to see alternatives available to companies.

The German legislation becomes effective in steps. The obligation to take back packaging became law on 1 July 1991 and legislation on the return of beverage containers and charging deposits on them becomes law on 1 January 1992. As a result of the legislation, German industry has a vision of supermarket staff suffocating under a sea of cardboard and plastic whilst irate customers queue for their returned deposits (Daily Telegraph, 1991).

Manufacturers and retailers must foot the bill for the new system - no public money is to be spent on the collection or recycling of packaging waste. But the huge expense is only one problem: so far there has been no study of the environmental implications of all the extra transport and reprocessing that will become necessary.

In fact, the German law could have detrimental environmental effects on the whole of Europe: it will create mountains of collected plastic and paper packaging - even crisp packets and fish finger boxes - which cannot be reprocessed resource-efficiently and are unlikely to be absorbed by the home market for reclaimed materials. The obvious way of recycling lightweight packaging made from mixtures of materials is through energy-from-waste schemes, but these will not count towards achievement of the targets laid down in the new law.

Both the legislation and the gentlemen's agreements are based on three key principles:-

- reduce the amount of packaging used
- reuse packaging
- recycle packaging, ie manufacture more packaging or other products with post consumer waste.

The target is to reduce the volume of waste material that has to be disposed of and here the aim is to reuse/recycle first and then to incinerate with energy recovery and as a last resort to use landfill.

All the legislation so far - Germany, Netherlands, EC and the UK Environment Paper (This Common Heritage 1990) all set targets for recycling of packaging. The EC directive and the German legislation aim at 60% of post consumer packaging waste to be recycled or reused. While to reuse may be suitable for some dedicated products - milk, Coca-Cola, it does present logistics problems.

Recycling of materials is a greater challenge. As it is a little distributed over a large area collection becomes expensive. Identification of different materials for sorting is difficult. Material has to be cleaned - removal of stale foodstuffs, oil or other obnoxious material can be difficult with some materials - plastic, paper fibre. So at the end of the operation, recycled materials are generally more expensive than virgin materials, can be more difficult to process, but most importantly may not be able to be guaranteed free of contaminants. There are however several exceptions to this where products are easily identified and segregated for recycling. An example of this is used Coca-Cola bottles which are made from PET as these can easily be identified by the labels, chopped up, cleaned and extruded in fibre fill which is used for padding anoraks and duvets. Old newspapers are another good example where they can be segregated, deinked and reused to make newsprint. Therefore new outlets must be found for all this material which will be collected for recycling. Because of the Food Safety Act, recycled paper and plastics cannot be used in contact with foodstuffs. It would appear therefore that financial incentives may have to be introduced to make recycling in general financially sound. New plants and equipment for processing recycled materials, especially paper, will also need to be installed if the targets are to be achieved.

There are similar problems with incineration. Poorly maintained incinerators have in the past caused a nuisance/pollution problem with local populations. National and European legislation on the control of flue gases from incineration now requires the operations to be strictly controlled and has eliminated any risks. However, the perception is still retained in the public's mind that they are a hazard. It is difficult to build new incinerators anywhere in Europe because of this misconception - the NIMBY syndrome (Not In My Back Yard). A recent planning application to build a power station, fuelled by household waste, in south east London has been rejected.

There are 32 incinerators operating in the UK to burn municipal waste and only six have heat recovery units. The remainder discharge the heat and carbon dioxide into the atmosphere adding to the greenhouse effect. The ash from such plants which can contain heavy metals is generally landfilled adding to the risk of pollution. However, modern technology has been developed which overcomes all the problems. The flue gases are washed to remove pollutants, the heat generated is recovered for communal heating systems or to generate electricity and the ash can be formed into a glass-like substance from which heavy metals cannot be leached out. The European plastics industry is lobbying governments to follow this approach, to install incinerators to generate electricity and to use oil saved to make new plastics. It does appear to make sense but the objections from the public will be difficult to overcome. The European Commission in their Draft Directive recognises the value of incineration with heat recovery but has set a maximum level of 30% of packaging to go to this method of disposal.

How does all this affect the pesticides business? There is of course the additional problem that used pesticides packaging can contain residues which mean that disposal is covered by the various Control of Pollution Acts and in some countries may only be handled by specially licensed companies. In many ways this is, perhaps, a bigger problem than the packaging legislation and, whilst the industry is the, or if not one of, most safety conscious in this respect, it will no doubt have a major affect on the way in which the business is conducted. Increasingly, companies which are producing products than can themselves cause environmental damage are introducing extensive product stewardship schemes where used packaging is collected after use and cleared ready for reuse or safe disposal. One major cleaning materials company in Denmark has set up a collection and weighing service for its used containers but it has tried to take special precautions to ensure the washing residues do not do any environmental damage on disposal.

From a safety aspect recycling of the product packaging is undesirable unless one can ensure that all traces of the product have been removed, so that only tin plate/steel or aluminium can safely be used in any general recycling scheme. The legislation will lead to more reusable containers dedicated to specific products with control devices to stop contamination being developed. Packs are also being developed with replaceable liners which can be taken out and reduce the total volume of packaging which has to be disposed of, for example, bag-in-the-box type packs where the box can be reused. There are of course proprietary lining materials which can be applied to plastics to protect against the pesticide being absorbed and then washed away after use, but this washing has to be carefully controlled to avoid pollution.

With the present legislation situation there is no clear way ahead - what is certain is that to meet the laws and dispose of used pesticide packaging safely, will cost more money which, at the end of the day, will have to be paid for by the consumer. It will also force changes in the way in which products are packed and sold and strategies will have to be developed to meet the challenge and to enable the industry to continue to flourish.

How quickly will these changes come about? If the European laws come into force as planned we have until 1996 at the most. Most targets for reduced volume, etc, set the year 2000 as the date when everything must be effective. In order to appear green, governments will no doubt introduce legislation more quickly. Already in some countries, notably Germany and Holland, companies need to be taking action to meet the targets set. Overall, I believe that the next 18 months will be critical and companies should have a packaging strategy developed that will meet the future challenge.

REFERENCES

Daily Telegraph (1991). Why Frau Schmidt will be taking back her toothpaste to the shop. *Daily Telegraph* 29.07.91.

Dutch Packaging Covenant (1991). *Packaging Covenant dated 20.04.91 between the Minister of Housing, Regional Development and Environment and the Stichting Verpackking en Milien.*

EEC Draft Proposal (1991). *Draft Proposal for Council Directive on Packaging and Packaging Waste XI/369/91* dated 27.05.91. Draft No 1.

Financial Times (1991). *Financial Times*, 09.08.91.

Swedish Agreement (1990). *Agreement between Swedish Ministry of Environment and the Swedish Plastics Packaging Industry.* July 1990.

This Common Heritage HMSO (1990). HMSO Publication, 1990.

REVIEW OF DESIGN OPTIONS FOR PESTICIDE CONTAINERS

A J GILBERT & C R GLASS

APPLICATION HAZARDS UNIT, MAFF CENTRAL SCIENCE LABORATORY, HATCHING GREEN, HARPENDEN, HERTS. AL5 2BD, U.K.

Abstract.

Currently available types of pesticide container are considered in the context of present design guidelines. The development of future guidelines for design of novel types of container is discussed, with particular attention paid to the associated regulatory constraints. A wide range of practical options for new designs of pesticide containers and delivery systems is explored and ways that the design of pesticide containers may evolve are discussed.

INTRODUCTION

This paper surveys design options for pesticides containers. It seeks to identify fundamental principles underlying common performance objectives for containers, which must be met by any adequate design. It outlines more detailed design features that distinguish alternative approaches to construction of different pesticide containment and handling systems, and it attempts to illustrate the good and bad features of design; indicating where the need for improvement, and scope for innovation, may exist. This paper does not set out to be definitive, nor to provide a blueprint for the design of an ideal container. Instead it intends to provide a broad review of currently evolving practice to assist those responsible for managing the development of improved systems for safe and efficient pesticide handling for the future.

Drawbacks in design of conventional containers for pesticides have been progressively recognised over recent years (Gilbert 1989), and improvements have been made in response, as illustrated by the Guidelines for the Design of Liquid Pesticides Containers (ACP 1990). The priorities of competing design features have been set by the combined aims of respective legislation, thus safety to people, wildlife and the environment (COPR 1986), together with user safety and convenience (COSHH 1988) should be assured.

Most recently attention has focussed on other aspects of packaging design and construction which have emerged as a new priority. Potential pollution by packaging waste will be reduced within the European Community (Anon 1991, 1) and, in all likelihood, also worldwide communities (Anon 1991, 2). It is possible that "green taxes" could be levied on packaging which cannot be recycled.

The discussion of feasible design options for pesticide containers of the future in this paper anticipates the establishment of new patterns in the industrial infrastructure. This is with the intention of illustrating where wide scope for innovation exists within a diverse industry. A multitude of novel forms of product and packaging can be developed alongside each other, which between them can establish raised standards of accuracy and safety in the routine handling and application of pesticides.

Viewpoints from within the industry have indicated that there could be fundamentally conflicting scenarios for the evolution of packaging within Europe. For example, one would be the development of a European 'standard' large, returnable container, which would be refilled by the pesticide manufacturer. Another would be the increased production of pesticides packaged in smaller, dose-related sizes of packs which would be more easily disposable (even bio-degradable). The authors' own view is more conciliatory, believing that industry should aim to gain the best of all worlds by evolving toward a more flexible range of systems which allow greater diversity and the ability to adapt increasingly to the specific demands of particular user groups.

CURRENT SITUATION.

The current British guidelines for the design of containers for liquid pesticides (ACP 1990) list features of container design which need careful consideration in order to ensure adequate performance of the container. Minimum design criteria must be met in order that approved pesticides can be supplied, transported, stored, and used in a manner safe to people, wildlife and the environment. To be considered suitable containers must:

- contain the product and prevent loss due to spillage, leakage or permeation during transit, handling and storage;

- give physical protection to the product and resist normal external forces to which the container will be subject during filling, storage, transit and usage;

- preserve the integrity of the contents by preventing direct or indirect chemical decomposition and provide protection against climatic conditions;

- allow instructions for safe product handling and use to be fixed securely;

- provide user safety and convenience during storage, handling, opening, pouring and disposal;

- be compatible, as far as possible, with pesticide filling attachments or 'closed' systems on application equipment.

These fundamental principles of container design should be complied with by both conventional and innovative types of pesticide container. The most common current types of container, for which draft design guidelines are currently being agreed (PLCD 1991, 1 and 2) are basically vessels of one sort or another (e.g. bottles, cans, drums, sacks, etc') which serve only to contain their contents. They require manual opening by users to dispense a required dose and must be re-sealable if not all the contents are used at once. These are essentially 'one-trip' packagings, that require the user to decontaminate and dispose of them after use. The Code of Practice for the Safe Use of Pesticides on Farms and Holdings (HMSO 1990) actually proscribes any re-use of an empty pesticides container other than to hold an identical product in the emergency circumstances of dealing with a damaged or leaking identical pack.

In addition to the general guidelines, certain recognised types of container have additional design guidelines to help them meet criteria appropriate to their intended usage or product field of use. Thus for products approved for home or garden use 'ideal' containers incorporate certain additional design features (ACP 1990, Annex 1) such as having small size, sufficient stability to be unlikely to fall over when stood upright on the base and to be virtually unbreakable in foreseeable circumstances of use. They should be resistant to opening by children. They would readily allow small doses of pesticide (e.g. that would be required to prepare one litre of spray) to be measured and dispensed without risking contamination of the user or spillage. The 'Home and Garden' pack is an example of specialised packaging and the next section of the paper describes and discusses key design features of what are currently recognised as other 'atypical' packaging options for pesticides.

LESS COMMON AND "NEW" DESIGN FEATURES

The container designs described in this section are currently regarded by the Pesticides Label and Container Design Panel (PLCDP) of the ACP as being 'innovative', although some of the ideas behind them are not new. They have recently gained recognition either because of attributes held to make them more suitable than simple conventional containers for the primary purpose of containing approved pesticides, or because they display other useful features, such as added safety, accuracy or convenience to the user, while not being less suitable for their primary purpose.

Liquid or solid pesticides supplied in water soluble packs.

Water soluble packaging (WSP) offers the combined advantages of disposability, reduced potential operator contamination and accurate dose control, by providing small dose-related sizes of packs that can be added to the spray tank as required. Potential disadvantages are the vulnerability of the WSP to degradation if it becomes damp/wet. Hence it requires an outer waterproof secondary packaging to protect it in storage and transit. Also, because those WSPs produced so far lack rigidity the secondary packaging has needed to be robust, especially for liquid formulations.

Data requirements (HMSO 1986) for approval of pesticides supplied in WSP call for testing of the chemical composition of the pesticide before and after storage in WSP, to determine any effects of the pesticide on the WSP and vice versa. Tests must encompass the relevant range of physical conditions (such as low temperature) which could foreseeably be encountered by the packaging in use. Similarly, data are required for solubility and physical testing of the product in the spray tank. The risk that dispersion of the product could be adversely affected by slow release from WSP or the presence of the solubilised WSP material in the spray tank must be addressed. The risk of undissolved WSP causing blockage of either the spray system or pesticide induction system also needs investigation.

Labelling requirements are the same for WSP as for any other pack in that all information essential for safe handling of the product needs to be carried. However, minimum labelling can be acceptable where handling of the pack (possibly with wet gloves) must be avoided and additional advice to place it into the spray tank directly from the outer pack, without additional handling, should be added where necessary (e.g. for liquid products).

Liquid or solid pesticides supplied in multiple compartment / multiple orifice packs.

Combination packs are a development of the advantageous concept of pesticides contained in unit dose sized packs, where the whole pack contents are added to the spray tank to treat an appropriate area. Additionally, these allow two or more different products, that are to be tank mixed, to be kept apart until they are dispensed into the tank in the correct proportions. The fact that users are advised to pour simultaneously from more than one opening in each pack, however, leads to the potential disadvantage of an increased risk of operator contamination and spillage during preparation of the spray.

There exist significantly different variations of design within the combination pack type. 'Twin packs' have the option of having a single closure screwed onto a single neck (covering two small apertures) or dual closures which each screw onto separate necks (each with its own aperture). Single neck packs tend to have very narrow apertures (<40 mm), which are associated with glugging of liquid dispensed through them. Attempting to pour controllably from two such narrow orifices simultaneously may increase the risk of operator contamination and spillage. Use of linked flexible plastic secondary seals may provide for sequential pouring of each liquid in turn, however in this process the seals may become contaminated with pesticide and become a hazard to the operator. Twin neck packs, on the other hand, offer the possibility of dispensing each product in turn, by removing the closures in turn. Also as each neck can feasibly have a wide aperture the operators ability to pour controllably would be improved. Operators attempting to pour simultaneously from twin neck packs are, however, unlikely to avoid spillage as the apertures, held horizontally or vertically adjacent, must be separated by several centimetres.

Due to the complicated geometry of the plastic mouldings of combination packs these are unlikely to be compatible with the couplings or suction probes of available closed filling systems unless a standardised design of twin pack neck can be agreed. The 'Packman' transfer system (Schering Agriculture 1990), which punctures, empties and rinses a very wide range of packs, has recommended twin packs not to be used with that system.

Liquid pesticides supplied in returnable packs.

In this section only small (<25 litre for liquids or <20 Kg for solids) packs are discussed in the context of being 'returnable' from the user back to their original source. Packs larger than this are discussed in their own right later. The idea of returnable pesticide packs, at its simplest, would merely add a less polluting and wasteful destiny to conventional packs. To close the currently open ended supply chain and to recycle empty packaging offers obvious advantage for the user in avoiding the problem of disposal. Disadvantages are that assurance must be provided that packs have been effectively decontaminated after emptying to render them safe for collection (although it is in the users interest not to throw away expensive product with the container), and that the trade infrastructure will need to be established so that the organised collection of empty packs is economically viable.

Current policy toward the handling of used pesticide containers varies widely around the world (GIFAP 1991). No legislation is available in some countries, whereas in others the advent of legal compulsion to return all packaging waste seems imminent (Anon 1991, 3). In any case, the successful development of policy aimed toward the reduction and recycling of pesticide packaging will depend on developments in the associated areas of decontamination of empty packs and the destiny of recycled materials.

The effectiveness of rinsing is crucial. Unrinsed packs must be disposed of as potentially hazardous waste, which is either expensive or polluting, or both. Rinsed packs, however, can either be disposed of more safely and easily or can be collected and re-used. Whole packs could feasibly be re-filled, although this would warrant some redesign of the new pack initially. Otherwise their materials could be re-utilised, either as raw material for other moulded plastic items or simply burned as fuel.

Container decontamination has been a major component of a study into current status, future goals and action plan for improved container management, carried out in the USA (NACA 1991, 1). Associated studies have considered efficiency of pesticide removal from the inner surfaces of containers by 'triple rinsing' techniques (NACA 1991, 2). Alternative rinsing methods themselves, such as pressure rinsing or triple rinsing have needed to be defined (Formulogics 1990) to provide assurance that containers cleaned by their users will actually be free from contaminants. It is important that any pesticides which are found to be hard to remove from their container by rinsing with water, according to standard procedure, carry a label telling their user to expect to dispose of these as contaminated waste. Hard rules are not yet agreed, but it is likely that a rinsing efficiency standard, of removal of not less than 99.99% of original contents, will become a working norm. The expense and inconvenience of present disposal arrangements may incline users to invest in equipment able to decontaminate packs, which would add a degree of assurance to the thoroughness of the process. A decontamination feature often accompanies the facilities of systems for automatic transfer of pesticides.

Necessary developments within the trade infrastructure and the possible development of financial inducements, to accommodate collection and disposal or refilling of returnable packs will probably limit the rapid adoption of returnable pesticide packaging. There is obviously an incentive for users to avoid the waste disposal problem, but there could be considerable expense involved for others if it was proposed simply to collect and recycle existing packs within the current supply framework. Ideally the financial and logistical burden of planned pack recycling would be shared among all parties concerned with pesticide supply and use. These parties would then all share the benefits from prevention of an avoidable source of pollution, as well as a potentially increased efficiency of supply of products where, when and only in the amount they are needed. A factor which would aid the ability of local users to return used packs would be the ability for local distributors to hold stocks of pesticide in mini-bulk containers. These are considered next.

Liquid pesticides supplied in large containers.

Large containers are typically around 300 - 500 litres in capacity and are by their nature 'returnable'. Pesticides are already supplied straight to end users in such intermediate bulk containers (IBCs) in other countries (e.g. USA and Canada); the user often being a contract applicator whose demand for product is high. Few U.K. users would have a sufficiently large requirement for pesticides to need their supply in large containers however. Thus in the United Kingdom, packaging evolution toward large bulk packs moving between manufacturer/supplier and the end user is unlikely.

A compromise solution might arise if the bulk pack were supplied to a local distributor who then in turn fills, or re-fills, the small packs of the end user. This would not aim to replenish the original 'one-trip' pack. Instead, users would need to obtain their initial supply of product in specially constructed multi-trip end user packs. These would be designed to stand up to multiple use over a longer period of time than current packs, although they will ultimately be a limited use item. They would need to undergo regular inspection and maintenance to ensure their continuing suitability for their purpose. Ideally, maximum advantage would be gained from evolution to such a supply infrastructure if the user's required dose is metered out at the distribution point. The user then needs only to pour out the whole contents of the re-filled container to treat their intended area or to fill the intended sprayer tank. This reduces both operator contamination hazards and the risk of user dose metering errors. Naturally, distributors would bear additional responsibility for both safe and accurate transfer of pesticides from bulk container to refilled small containers. However, it is reasonable to expect distributors to be willing and capable of taking this on, with the expectation of offering their customers in turn a 'COPR/COSHH' friendly service, as the user needs to obtain, in vessels purpose built to fit the farm or the sprayer, only the required amount of product for their treatment (avoiding waste) and with minimal need to handle concentrated pesticide.

Ultimately, the user may wish to develop further the advantage of packs filled according to their needs by substituting the 'small' pack with a larger concentrate reservoir that could be a detachable component of the spray machine. Reservoir(s) could be (re)charged at the distribution point, or from a mobile 'tanker' for larger sprayers, with the amount of pesticide to be used for a particular job. The product is then drawn from the reservoir only as required to be sprayed out; being mixed in the line. This would potentially avoid any need for the operator to contact the concentrated pesticide at all. A potential disadvantage lies in the need to develop standard adaptors to connect IBC's with refillable vessels, but this would be technically feasible.

A more serious potential disadvantage with adoption of IBCs in general lies in the need to ensure continuity of responsibility for safe product handling (not allowing the product to contaminate the container nor to allow contaminants to enter the product) and to ensure correct labelling follows the product as it is transferred from one container to another. COPR 1986 places legal obligations on those concerned to ensure correct labelling accompanies a pesticide, while safety matters are predominantly a matter dealt with under COSHH regulations 1989. Manufacturers who themselves may have valid concerns to ensure their products are safely and properly delivered to their end user, via third party distributor(s), might see an advantage in the adoption of an established quality assurance management scheme such as that offered by BS 5750/ISO 9000 (BSI 1987).

Adaptor-packs.

Use of pesticide concentrate containers as reservoirs on large spray equipment may develop in the future. This approach has already become a favoured option for small hand held sprayers. This section discusses pesticide packaging which is designed to have a double function; also serving as part of the application system for the product. This is a grey area, as there are few definitions to distinguish between 'concentrated' vs. 'dilute' products nor application equipment and associated engineering controls for transferring pesticide between vessels during its preparation for use. For this discussion, adaptor-packs comprise all purpose designed containers, having technical features appropriate to allow them:

a) to supply liquid pesticide in containers capable of

being attached to closed transfer systems or in-line mixing systems to fill equipment which itself applies the product.

or, b) to supply liquid or solid pesticides in a container which when attached is an integral part of the application system or is its pesticide reservoir.

In principle, conventional liquid bottles of five litres and above in volume, which have the industry standard 63 mm diameter neck with ASTM thread (GIFAP 1990) could qualify as adaptor-packs. These would be likely of being capable of direct attachment to closed transfer systems or in-line mixing systems so they could be used to charge small or large sprayer tanks or be carried on a sprayer to feed concentrate to the spray line for dilution before application. There are, however, limitations to this line of co-evolution of containers and application equipment. Sprayers on vehicles would probably need to carry more than five litres of concentrate, so are likely to have a concentrate reservoir integral with the sprayer (as on purpose built in-line mixing systems), or may use larger conventional packs with industry-standard necks connected by manifold concentrate induction lines linking several packs into the system. Hand held sprayers would be disadvantaged by needing less than five litres of concentrate per working day and containers smaller than five litres may not have the industry-standard neck. Thus hand-held sprayers are more likely to have more sophisticated receptacles for supplying them with either concentrated ready to use pesticide for direct application than offered by simple bottles.

Well known examples of purpose designed adaptor-packs that already exist include the Nomix system and Ciba-Geigy Transformer for herbicide spraying, the ICI Electrodyn electrostatic sprayer and the Turbair mistblower. These systems apply ready to use products from 'bottles' which attach directly to the applicator. Ideally, they need no operator involvement with preparation of pesticide. This potentially avoids the risks of operator contamination by concentrated pesticide or of dilution errors when preparing the product for use. In a truly closed system the approved product container is attached directly to the application equipment without needing to be opened at all by the operator. In other 'closed' systems the pesticide container may become the reservoir of the spray application equipment but a significant difference may arise if the product comes as a concentrated liquid requiring the operator to gain access to the pesticide in the pack to prepare it for use before attaching the pack to the sprayer. Such a system is closed during transfer of pesticide from the pack to the applicator, but the potential for operator contamination by both the concentrate and the dilute pesticide would exist during the preparation of the product for use. These systems all would potentially offer their operator a safer alternative than pouring concentrated liquids from bottles.

Adaptor-pack systems share the common feature of having unique packs dedicated to be fitted to specific application systems. The accuracy of dosage supplied to the atomiser depends on the quality of pack and of the application system it is dedicated to. Liquid flow rate from the pack must be consistently controllable to provide the operator with confidence in dose control.

For very small hand held sprayers (five litres or less) there exists the 'dosing cap' whereby measured doses of pesticide sufficient to make up whole numbers of litres of dilute spray are supplied as a solid formulation held inside a screw on cap that fits the intended sprayer. By fitting the water filled sprayer with a new cap and shaking it the user can prepare the right dilution of product. Accuracy of dilution is determined by the correct measurement of the dilution water into the sprayer.

For other conventional hand held lever-operated knapsack (LOK) or compression sprayers there is a further option which could provide both more accurate dosing and reduce the risk of operator contamination. Down Fluid Injection (Fluid Technology, Undated) provides a system whereby pesticide is displaced from the flexible inner bag, held within a PET bottle, by allowing the pressurised water in the spray line to enter the space between the bag and the bottle wall. The system is able to dispense the correct proportion of concentrate to diluent because it directly applies diluent water pressure to the outside of the concentrate bag. The sprayer pressure must be accurately regulated, which is achieved by retro-fitting with a 'Spray Management Valve' (SMV), which is capable of accurately maintaining exactly the set pressure when any liquid is sprayed (Matthews 1991). This system is currently undergoing U.K. and overseas trials to verify the accuracy of dosing and dilution and to characterise the operator exposure risk. Because the pesticide does not contact the walls of the PET bottle there could be scope for recycling this item to be repacked with pesticide in a new inner bag.

CONCLUSIONS.

Key topics to be considered in the complex evolution of pesticide packaging in the future are pack dispensing (handling safety and dosing accuracy), combination packs, pack rinsing, pack disposal (including WSP), returnable packs, closed system packs, mini-bulk containers and adaptor-packs. Delivery to the user of improvements in the ways of packaging pesticides will depend upon adaptations to the industrial infrastructure for supplying the user and innovation in packaging and handling technologies. For wide adoption, investment will be required, so incentives must be found to attract the market. Initiative is with the industry.

REFERENCES.

Anon (1991, 1) Europe environment 364, May 1991 p6

Anon (1991, 2) Pesticide and Toxic Chemical News Feb 6 1991 p36

Anon (1991, 3) Chemistry in Britain 1991 27 (8) p694

Advisory Committee on Pesticides (1990) Guidelines for the design of containers for liquid pesticides. ACP 94/211 (1990).

BSI (1987) BS 5750/ISO 9000:1987 - An executive's guide to the use of the UK National Standard and International Standard for Quality Systems. BSI Quality Assurance, P.O. Box 375, Milton Keynes MK14 6LL, U.K.

Fluid Technology (Aust) Pty Ltd (Undated) DFI Technology, precise proportional injection. Leaflet available from 17 Pearson Way, Osborne Park, Western Australia 6017.

GIFAP (1990) 63 mm Industrial-Standard opening. GIFAP Task Force Packaging, Dormagen 17.09.1990

GIFAP (1991) Summary of the existing situation regarding container disposal. Packaging Task Force report C/91/TD/258, GIFAP, Avenue Albert Lancaster 79a, 1180 Brussels, Belgium.

Gilbert A J (1989) Reducing operator exposure by the improved design and handling of liquid pesticide containers. 1989 British Crop Protection Conference - Weeds 1 593 - 600

HMSO (1985) Food and Environment Protection Act (1985), Her Majesty's Stationery Office, 49 High Holborn, London WC1V 6HB.

HMSO (1986) Data requirements for approval of pesticides under COPR 1986 Her Majesty's Stationery Office, 49 High Holborn, London WC1V 6HB.

HMSO (1988) Control of Substances Hazardous to Health Regulations (1988), Her Majesty's Stationery Office, 49 High Holborn, London WC1V 6HB.

HMSO (1990) Code of Practice for the Safe Use of Pesticides on Farms and Holdings, Her Majesty's Stationery Office, 49 High Holborn, London WC1V 6HB.

Matthews G A (1991) Personal communication. International Pesticide Application Research Centre, Imperial College at Silwood Park, Ascot, Berkshire SL5 7PY, U.K.

PLCD (1991, 1) Design of paper sacks to contain pesticides. Pesticides Label and Container Design Panel (Draft) paper 10/3.

PLCD (1991, 2) Design of containers for solid pesticides. Pesticides Label and Container Design Panel (Draft) paper 10/4.

Schering Agriculture (1990) 'Packman' Technical Product Information brochure. Schering Agriculture, Nottingham Road, Stapleford, Nottingham NG9 8AJ, U.K.

COMMERCIAL EXPERIENCE WITH A REFILLABLE HERBICIDE SYSTEM IN WESTERN EUROPE

S. MOLL

MONSANTO Europe S.A., Avenue de Tervuren 270 - 272, 1150 Brussels, Belgium

ABSTRACT

Refillable mini-bulk systems ranging in size from 115 to 400 litres were commercially test marketed in four West European countries with either glyphosate or alachlor based herbicides. Farmer users identified three major benefits from use of these systems : elimination of empty pack disposal problems, ease of use, and reduced operator exposure. Whilst this system was accepted by the large volume herbicide users participating in the project, the relatively small size of European farms will limit the use of the mini-bulk system to specific niche applications.

INTRODUCTION

The use of refillable systems for crop chemicals has over the last ten years become widespread in the United States, and more recently in Canada. In North America, large average farm size and focused cropping patterns have facilitated the replacement of one-way plastic jugs with 30-200 U.S. gallon returnable mini-bulk systems. Whilst farmers may enjoy modest price discounts from large volume purchases, the main factors driving adoption of mini-bulk systems has been handling benefits, and elimination of the need for disposal of one-way plastic or metal containers.

Since the introduction of mini-bulk systems in the United States for the herbicide alachlor in 1986, it has been estimated that 15 million plastic alachlor containers have been substituted, representing an elimination of over 4000 tonnes of plastic waste. Whilst refillable mini-bulk containers do have a finite life - approximately five years in the case of alachlor containers, a disposal programme has been established whereby empty mini-bulk tanks are recycled for energy generation. The low-density polyethylene used in mini-bulk tank construction is a rich energy source - 100 x 100 gallon containers yielding an energy value equivalent to approximately 9 tonnes of coal.

Through a Container Management Task Force, the United States National Agricultural Chemical Association (NACA) is encouraging industry members to reduce the number of empty containers by means of an integrated container management approach, which includes increasing volumes of product sold through refillable packaging systems. A survey conducted by NACA in 1990 showed that in 1989, approximately 20% of liquid crop chemical products in the United States were supplied in refillable containers.

Awareness of crop chemical container disposal issues have dramatically increased in Europe over the past few years. This has been driven not only by impending pack disposal legislation in EC countries such as Germany, but also by a demand from the farmer consumer to minimise environmental impact from waste disposal. From an industry perspective, crop chemical manufacturers are giving high priority to development of innovative product delivery systems which improve handling and the environmental profile of existing products. Set against this background Monsanto Europe planned a commercial test marketing programme where returnable mini-bulk systems, based on the proven North American Shuttle™ models could be commercially tested in Western Europe.

COMMERCIAL TESTING IN EUROPE

Equipment

Three sizes of returnable mini-bulk containers were tested in Europe with glyphosate and alachlor based herbicides. A 200 litre and 400 litre container based on the U.S. 60 and 100 gallon models and a 115 litre drum based on a 30 U.S. gallon Canadian system. Containers were factory filled and supplied to users together with an electrical diaphragam pump, powered from a standard 12 volt tractor battery system.

Test Marketing Programme

Returnable mini-bulk systems were test-marketed in four West European countries in 1990 and 1991.

Country	Product	Mini-bulk system
France	Alachlor (480 g/l EC)	400 litre
Italy	Alachlor (480 g/l micro-encapsulated)	200 and 400 litre
Denmark	Glyphosate (360 g a.e./l)	115 litre
Germany	Glyphosate (360 g a.e./l)	400 litre

Numbers of refillable units in each market test varied from 25 in Denmark to 400 in France.

RESULTS

Container handling

Feedback from participants in the Danish test indicated that the 115 litre container was very difficult to handle - it being too large to move manually, and too small to be readily handled by pallet handling or hoist equipment. The unsuitability of this 115 litre system was confirmed by qualitative market research in the U.K. where farmers and dealers rejected this system on the basis of it's negative handling characteristics. Whilst these conclusions may not seem surprising in a European environment, the same 115 litre system has proven to be extremely well accepted in Canada since it's launch in 1990.

The larger containers tested (200 and 400 litre capacity) have all been very well accepted by both the distributive trade and farmer users. These custom-made containers are fitted with an integral pallet to facilitate handling with fork-lift equipment or hoists.

User benefits of refillable mini-bulk systems

Follow up questionnaires completed by users yielded a number of advantages and benefits arising from use of the mini-bulk system, compared with standard one-way containers.

The ranking of benefits varied between countries :

France

1. Ease of use (quicker filling of sprayer, accurate dosing, easy to move)
2. No physical contact with the product
3. No pack disposal problem

Italy

1. No pack disposal problem (every user questioned ranked this benefit first)
2. Easy of use
3. No physical contact with the product

Denmark

1. No pack disposal problem
2. Easier sprayer loading (no lifting of containers, accurate metering of product)

Germany

Results from this 1991 test not available at time of publication.

90% of the European mini-bulk test market participants indicated that they would repurchase product in the mini-bulk system. The major criticism of the systems centred around the pumping mechanism. Despite the fact that two makes of pump were tested, a significant number of users had difficulty in calibrating pumps and carrying out routine maintenance. Whilst lack of familiarity with bulk pumping systems may have been led to these issues being raised, a simpler hand-operated pump is being commercially tested in Germany during summer 1991.

Logistical management of mini-bulk refilling

In the United States, refilling of mini-bulk systems is typically handled within the manufacturer's dealer network. In the intensive row-crop area of the mid-West, dealers are equipped with bulk-storage systems for a range of herbicide products. Normally farmers will take the (product specific) mini-bulk container to a dealer for refilling two or three times during the application season. In these intensive arable areas up to 70% of maize and soya bean herbicides are used in mini-bulk systems. With no comparable logistical infra-structure in Europe, the refilling operation with alachlor and glyphosate has to date been managed on an annual refill basis. Mini-bulk containers have been returned at the end of the season to a central manufacturing plant for cleaning, maintenance, and refilling.

THE FUTURE OF REFILLABLE HERBICIDE SYSTEMS IN EUROPE

Equipment

Results from commercial experience with alachlor and glyphosate herbicides yielded two basic conclusions. Firstly that containers must be easy to handle on farm - this may lead to a polarisation of refillable container sizes; either small enough to be manually moved (20 - 30 litres), or large enough (200 - 400 litre) to be custom fitted for movement by material handling equipment.

Secondly, pumping equipment needs to be robust, simple to use and provide accurate metering. These criteria may not always be easy to meet bearing in mind the cost of refillable systems is another important parameter which will govern user adoption.

European farm structure

In the mid-West of the United States, well over 70% of alachlor herbicide is supplied through mini-bulk systems. Two factors have driven this intensive usage : a large average farm size and an intensive two crop maize/soya bean rotation, which receive a relatively simple crop protection program - compared with, for example West European cereal crops.

A relatively small average European farm size, heterogeneous cropping patterns, and intricate crop protection programmes do not lend themselves to widespread adoption of refillable mini-bulk systems. However, ideal market conditions for mini-bulk do exist in some West European localities - the Lande region in France where 400 litre alachlor containers are in their second commercial year, is an area with an agronomic profile similar to the mid-Western United States.

Adoption of returnable mini-bulk systems

Based on our commercial testing I would conclude that returnable mini-bulk systems will not become a dominant packaging system in Western Europe. Nevertheless, our experience during market test programmes indicate that for contractors or large farms, which are equipped with materials handling equipment, this form of delivery system has proven to be very well accepted. It is of course contractors and large arable units where major benefits of a returnable mini-bulk system can be realised. High volume crop chemical users have large areas to spray in a short time, have a large number of packs to handle - and have large numbers of containers to dispose of.

In conclusion, I believe this type of refillable herbicide system can offer improved product handling on large arable units - and make a significant contribution to the reduction of waste arising from one-way packaging.

REFERENCES

Anon Summary of National Agricultural Chemicals Association meeting - Container Management Goals : Status and Action Plan 1991.

DEVELOPMENT OF A SPRAYER TANK WASHING SYSTEM

W.A. JEFFREY

The Scottish Agricultural College (Edinburgh), Scottish Centre of Agricultural Engineering, Bush Estate, Penicuik, Midlothian, EH26 0PH

ABSTRACT

By minimising the volumes of washings produced, a low volume tank wash system makes it practical to flush the tank and spray out washings before leaving the field. Cost savings are possible where washings are collected for removal by contractor, or where they are processed by a treatment plant. At the Scottish Centre of Agricultural Engineering (SCAE) a flush system using static nozzles was installed in a sprayer used for trial work in 1989. Subsequent efforts to improve coverage of the tank surface resulted in the development of a rotating, angled swash plate type nozzle for mounting in the top of the spray tank. Two flushes using a total volume equivalent to 13% of the tank capacity have shown comparable contamination levels in the tank to the traditional fill to the brim method. In practice, the wash volume will be dictated by both tank capacity and the volume contained in pipework on the sprayer.

INTRODUCTION

Recent legislation has reinforced the stringent duty on all pesticide users to avoid pollution of the aquatic environment. Avoiding exposure of the sprayer operator and other people is also a priority, particularly where the pesticide has a hazard classification. One result of these restrictions has been to bring about a profound re-appraisal of how users handle and dispose of pesticide wastes, including the dilute waste generated when washing out sprayers.

The MAFF/HSC code of practice for the safe use of pesticides on farms and holdings (1990) suggests 7 possible routes for the disposal of dilute pesticide waste at low concentration. Earlier draft versions of this code concentrated on the use of soakaways and sacrificial areas, with the approval of the National River Authority in England and Wales, or the appropriate River Purification Board in Scotland. Such approval was seldom forthcoming; in Scotland the proximity to water courses of most agricultural land means that suitable sites for either disposal method are rare. Disposal to a sewer may be feasible in a few cases; storage for collection by a licensed waste disposal contractor or processing through a treatment plant will be prohibitively expensive for the majority of individual farms. In most practical situations, sprayer washings will have to be sprayed out in the field - either onto a reserved strip, or by over-spraying in the treated area (subject to the terms of the product approval).

The conventional method of rinsing the tank after use is to fill it to the neck. Any disposal facility for washings must be able to accept at least one tankful of contaminated water. Clearly the problem will be relieved by any measure which reduces the volume of washings produced. Hand lances and pressure washers have been used, but with no guarantee of success in larger tanks, and there is an inevitable risk of splash contaminating the operator. A built-in flush system removes the operator contamination risk, and should be quick and easy to use. Cleaning water may be carried to the field either in a separate tank on the sprayer or in a field bowser, encouraging operators to wash out immediately after spraying is completed.

By minimising the quantity of washings produced, a flush system also allows cost savings where washings are collected for removal by contractor, or where they are processed by a treatment plant.

At SCAE the original aim was to help users to comply with the code of practice by providing a tank flush system which could be retro-fitted to existing sprayers. The priorities were that it should be a low cost system, easy to fit and use, and require about 10% of the conventional flush volume to ease disposal of the washings.

THE SCAE TANK FLUSH SYSTEM

Development of the flush nozzle

The initial flush nozzle was a fixed, 360° dispersion plate (Fig. 1) based on an existing component intended as an anti-vortex tank outlet. Two of these were fitted into a 600 litre sprayer with a 12 m boom. This particular sprayer was equipped with various accessories for trial work, including additional boom return hoses hanging inside the tank. When operating, the flush system diverts the flow in the 'spray-off' return line (Fig. 2) to the two flush nozzles, giving a wash down action on the tank walls. To establish whether all the tank surfaces were being effectively rinsed, a water soluble blue emulsion was spray painted over the inside of the tank. Washing down with the fixed dispersion plate nozzles left unwashed shadows behind the several hose clusters, and also in narrow rings close to the nozzle bodies.

At that time, the author was not aware of any alternative nozzle that was entirely suitable for the location and flow rates required, and also reasonably priced. It was desired to keep the nozzles at the top of the tank, partly to minimise the risk of leakage where they pass through the tank wall, and partly to avoid blockages or gumming up following immersion in dilute pesticide. To improve on the performance of the fixed dispersion plate, two major modifications were required: i) the plate should rotate, with liquid departing from it at various angles in plan view - to wash behind narrow obstructions like hoses; ii) the plate should be inclined in side view, to wash out a mushroom shaped space as it rotates, with those parts of the tank wall below the 'mushroom' rinsed by a flush down effect.

Implementing these modifications resulted in the rotating, angled swash plate nozzle dubbed 'Rotaflush' (Fig. 3). All rights and patent protection on the design have been assigned to British Technology Group. The nozzle comprises a moulded rotor running on a stainless steel spindle, and retained by a PTFE thrust washer backed by a stainless steel circlip. The spindle is supported by a moulded bulkhead fitting incorporating water passages to feed the rotor. There are no small apertures or jets to block up. The nozzles are sized to operate on flow rates from 40 l/min at minimal pressure, allowing two nozzles to be fitted to the smaller sprayers with pump capacities of around 100 l/min. Larger tanks tend to come with bigger pumps, giving higher flow rates. The greater throw resulting from a 200 l/min pump means that two nozzles are still usually adequate for tanks of up to 2000 litres. Larger, awkward shaped or partitioned tanks may use three or more nozzles, provided there is sufficient pump capacity to supply each with at least 40 l/min.

Where the flush system is plumbed in depends on the existing plumbing on the sprayer. The aim should be to flush as much as possible of the sprayer pipework while flushing the tank. For example, by tapping into the master return hose on sprayers fitted with a single on/off control, all the pump flow is diverted to the flush nozzles after first rinsing the on/off control. On larger sprayers fitted with constant pressure control systems, the flush system can be tapped into the end of the boom section control manifold so that the manifold is also flushed. As the flush nozzles operate at

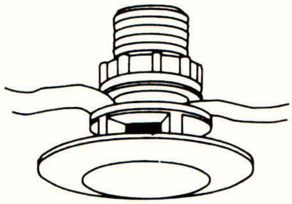


Fig. 1 360° dispersion plate nozzle

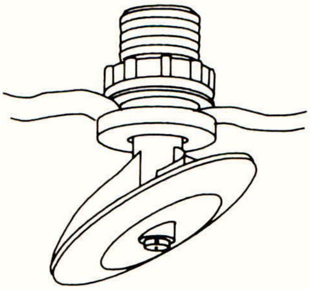


Fig. 3 Rotating, angled swash plate nozzle

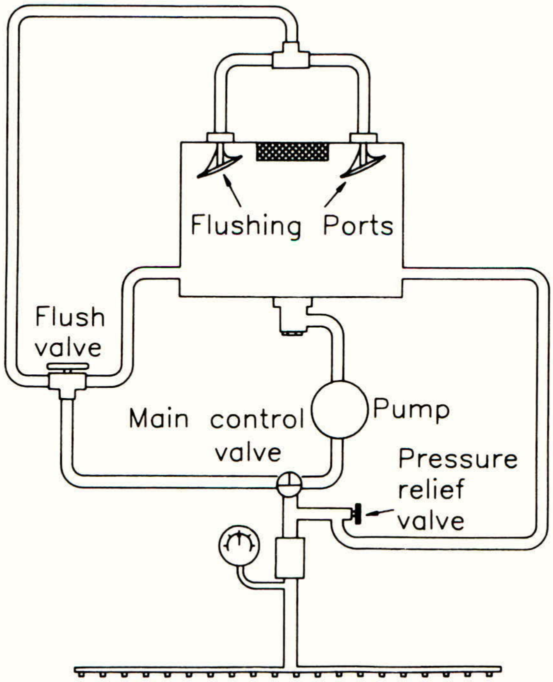


Fig. 2 Flush system plumbed into 'spray-off' return hose

less than the normal spraying pressure, the by-pass circuit in the pressure control valve will remain closed, delivering the full pump flow to the flush system.

Residue tests

The final design of the flush nozzle left no obvious trace in further wash-off tests with blue emulsion. To establish the degree of decontamination obtained by low volume washing, two sets of tests were conducted using a manganese foliar feed solution ('Vytel' chelated manganese) as a tracer. The first was to check the effectiveness of cleaning the spray tank in isolation, the second included flushing the tank washings through the boom and nozzles to simulate a wash and spray out in the field.

Spray tank only

The inner surfaces of a 600 litre sprayer tank were coated with a low concentration Mn solution. Two tank swabs were taken to establish the original contamination level before washing out. The solution was then drained and 40 litres of clean water added. The flush nozzles were operated for 2 minutes, and then the wash solution was drained. Four swabs were taken from marked locations in the tank. The flush procedure was repeated and four further swabs taken from the same location.

After thorough cleaning with a large volume of water, the tank was again coated with the same concentration of Mn solution and drained. The tank was then filled to the brim with clean water and left for 10 minutes before draining and taking further swabs.

Each swab was weighed before and after to obtain the weight of liquid absorbed before analysis for Mn content. This allows the Mn content to be expressed as a concentration in the residual solution on the tank walls.

TABLE 1. Mn concentration in swabs taken from spray tank walls, g/kg, following flushes with 40 litres and soaking with 600 litres water

Before rinsing (mean of 2 swabs)	1st flush (mean of 4 swabs)........	2nd flush	soak
1.22	0.21	0.05	0.05

Tank, hoses and boom

The greatest contamination of a subsequent spray solution will occur when the spray is first turned on, and then decline as the pipework is purged by the new solution. To determine this initial residue level after washing out, a small amount of water was pumped through the sprayer onto a series of trays under the spray boom. Again, washing out by a series of low volume flushes was compared with a full tank soak. These procedures were conducted using a typical 800 litre capacity, 12 m boom sprayer.

Prior to each test, 100 litres of Mn solution at a nominal concentration of 1000 mg/l was added to the tank, and the inner surface coated by using the flush nozzles. All the solution was then sprayed out. Following each washout procedure, a further 20 litres of water was added and sprayed out over 5 trays spaced out under the boom. The spray jets fitted were BCPC code F110/3.20/3, operated at 3 bar pressure. Samples were then taken from each tray for residue analysis.

In the first procedure the tank was filled to the brim with clean water and allowed to soak for 30 minutes. All the cleaning solution was then sprayed out.

In the second and third procedures, the tank was rinsed by one and two flushes respectively through the flush nozzles. Each flush used 30 litres of water and lasted for 2 minutes. All the tank contents were sprayed out after each flush.

TABLE 2. Residual Mn concentration, mg/l, in spray samples collected after washing out a solution of 1000 mg/l.

Wash procedure	Total volume (litres)	Tray position 1	2	3	4	5	Mean
Soak	800	7.3	6.5	7.1	6.7	7.8	7.1
1 flush	30	53.3	33.2	37.6	36.7	94.1	51.0
2 flushes	60	3.5	0.9	1.5	0.9	5.7	2.5

Discussion

It was suggested in training literature (BCPC/ATB) that several rinses with a small volume can be more effective than one rinse with a large volume. The swab tests show a dramatic reduction in residues on the tank walls after the second flush compared to the first. Similarly, contamination of subsequent sprays (Table 2) following two low volume flushes was no more than after filling to the neck. A third flush could reasonably be expected to leave less residue.

It has been shown that, in a similarly sized sprayer, the pump, controls and pipework have a capacity of around 9 litres (Taylor et al, 1988). When rinsate from the tank is sprayed out, residual solution in the pipework downstream of the controls will mix with the rinsate to some extent before being expelled. Had perfect mixing occurred, then assuming a capacity of 10 litres in this pipework the expected concentrations in Table 2 would be 83 and 21 mg/l respectively following one and two low volume flushes. Despite the addition of residues washed off the tank walls, the concentrations found were less, indicating that perfect mixing did not occur. High flow rates are preferable when spraying out, to minimise mixing time in the pipes - tests with a similar sprayer fitted with smaller jets (BCPC F110/1.60/3) produced slightly higher residue levels.

The rinse volume required depends on pipework capacity as well as tank size, so that a 24 metre boom may need four times the rinse volume of a 12 metre boom. Again, repeated rinses with a smaller volume should give better results than fewer rinses with a large volume.

Further developments

It is inevitable that closed ends on boom manifold pipes will form residue traps, unless end plugs are removed for washing out. Trays 1 and 5 in Table 2 were placed close to the outer ends of spray boom, and the residues from these were consistently higher than the other trays. It should be possible for boom manifold sections to have return hoses, as already fitted to some sprayers, plumbed so as to permit reverse flushing of the boom pipework by use of a Venturi. Venturis used to be a common fitment to provide 'suck back' as an anti-drip measure before reliable anti-drip valves became widely available.

Flushing the boom tubes and hoses would reduce the chance of residue pockets being left in the pipework where washings must be sprayed out (ie pumping through the boom with nozzles and bar end caps removed is not permissible). The boom pipework should only be flushed during the first wash out, to encourage rapid purging of the pipes during subsequent washes. Reverse boom flushing could remove the need for a collection trough where washings are collected for treatment or off site disposal.

CONCLUSION

Low volume tank flush systems such as that described provide a convenient method of washing out sprayers while reducing the risk of pollution arising from disposal of the washings. The capacities of both tank and pipework on the sprayer must be considered when deciding how much wash solution is needed. Two or more rinses with a small volume can give better results than one rinse with a large volume. To include boom pipework in the flushing operation, sprayer manufacturers should be encouraged to fit closed loop boom plumbing, and consider the provision of a suction flush facility.

In recognition of the value of tank flush systems in reducing the volume of dilute waste produced, the latest (1990) version of the MAFF/HSC code of practice now recommends the use of an efficient tank flushing system in the sprayer.

REFERENCES

British Crop Protection Council; Agricultural Training Board (1991) Boom sprayers handbook.

Ministry of Agriculture, Fisheries and Food; Health and Safety Commission (1990) Pesticides: code of practice for the safe use of pesticides on farms and holdings. HMSO.

Scottish Agricultural College (1989) Interim guidelines for the disposal of surplus dilute pesticide and tank washings from sprayers. *Technical Note 188.*

Taylor, W.; Petty, S.; Oliver, R. (1988) Some observations quantifying and locating spray remnants within an agricultural field crop sprayer. *Aspects of Applied Biology 18, Weed Control in Cereals and the impact of Legislation on Pesticide Application.*

Tracer solution 'Microfeed Vytel' chelated manganese as Mn EDTA, in solution equivalent to 6.4% w/v Mn; Rhone-Poulenc, ABM-Sturge Division.

A SYSTEM FOR THE TREATMENT OF WASTE WATER FROM AGROCHEMICAL PRODUCTION *AND FIELD USE*

D A HARRIS*, K S JOHNSON#, J M E OGILVY

ICI Agrochemicals, Fernhurst, Haslemere, Surrey, GU27 3JE, UK.

ABSTRACT.

A process of chemically induced flocculation followed by filtration through activated carbon has been shown to be very effective in removing pesticides from waste water prior to disposal or re-use. Large plants treating up to $100m^3$ per day have been used in agrochemical manufacturing for the past 20 years. The process has now been miniaturised and packaged for use by small-scale generators of waste water such as research stations, field trials teams, farmers, horticulturalists, and small formulation sites. A range of simple and cost-effective equipment to use the process has been specially developed. Capacities range from 0.3 to $5m^3$ batches and the self-contained plants can be operated by non-specialist personnel without the need for laboratory support. Removal of active ingredients to below the best levels of detection has been consistently achieved.

The system brings for the first time economical on-the-spot treatment within the reach of relatively small industrial or agricultural enterprises.

1. INTRODUCTION

The treatment of water effluents produced in the manufacture and formulation of agrochemicals in large-scale operations has been routinely practiced for over 20 years. Although considerable development of engineering detail in the plant has taken place during that time, the basic process has remained the same and has been found to be consistently effective in removing active ingredients and most formulating agents from waste streams prior to their disposal. The process converts large volumes of dilute unmanageable waste water into small volumes of easily managed waste and large volumes of cleansed water.

Until recently little attention had been given to the question of disposal of small volumes of waste water generated by medium and small-scale operations of any type. Disposal without treatment to sewers, soakaways or waste land was normal and this was considered acceptable because the volumes and concentrations involved were low and the risk of pollution was perceived to be minimal.

*Present address - Sterling Services, 5 Upperfield, Midhurst, Sussex, GU29 9AE, UK.

#Present address - East Peckham Environmental Consultants, 78 Pound Street, East Peckham, Tonbridge, Kent, TN12 5BJ, UK.

This view of small-scale waste has dramatically changed in most countries during the past 10 years. In the UK, society has demanded stronger laws to prevent pollution of the aquatic environment and to protect drinking water. The Government has responded with stringent legislative controls including The Food and Environment Protection Act (FEPA) 1985, Code of Practice for the Safe Use of Pesticides on Farms and Holdings, 1990 and The Environmental Protection Act (EPA) 1990. The EPA imposes strict controls on all aspects of environmental pollution and in particular the 'Duty of Care' which legally requires waste producers to ensure all wastes are disposed of safely, legally and without adverse effect on the environment. These requirements will be monitored by Government enforcement bodies - namely Her Majesty's Inspectorate of Pollution (HMIP) and the National Rivers Authority (NRA). The principle that the polluter pays is now the basis of environmental protection and this is accelerating the rate of change.

With these anticipated developments in mind work began in 1981 to find a way of bringing to the small-scale producer of waste water, the process which had been proved in use in the large-scale factory environment. The problems requiring solutions included removing the need for skilled and highly trained specialists to supervise and adjust the process, eliminating all monitoring and measuring instruments and producing simple but reliable equipment and a treatment package at prices the small user could afford.

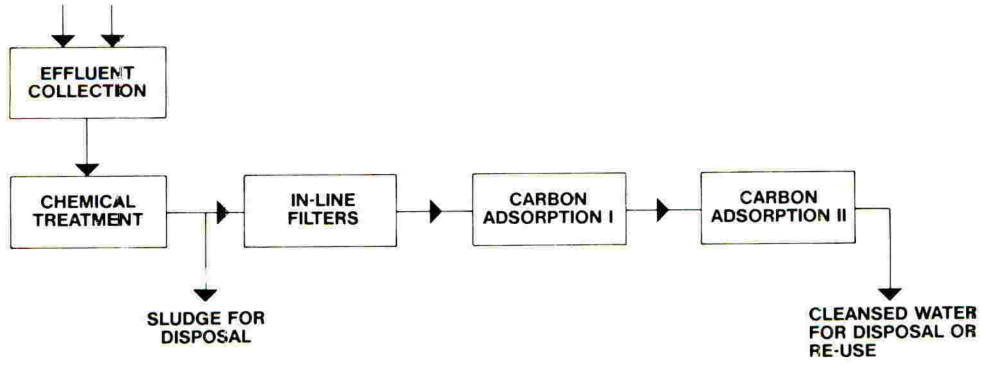
2. THE ICI 'CARBO-FLO' WATER TREATMENT PROCESS

Most agrochemicals have a low solubility in water and are usually manufactured in the form of wettable powders, suspension concentrates or miscible liquids. Agrochemical formulated products usually consist of complex mixtures of low solubility active ingredients, solvents and oils with a range of water soluble adjuvants including surfactants, stabilizing agents and in some cases dyes. The treatment process for effluents and wash waters containing agrochemicals is shown in Fig. 1 and operates in two stages:-

i. Chemical flocculation and settlement of all suspended matter, including most of the active ingredients.

ii. Activated carbon adsorption of the clarified effluent to remove soluble organic residues including traces of pesticides.

Figure 1. The Process



The key to the successful adaptation of this basic process is the use of essentially inorganic, non-toxic and easy to handle flocculating and adsorbent materials which are pre-packed for one batch treatment. The operator has only to add these materials in a numbered sequence and observe simple operating procedures. The standard treatment for a $1m^3$ batch weighs about 3Kg and is packed in four bottles, three containing solids and one liquid. These are suitable for treating dilute effluents with a total organic content not exceeding 0.3%. However, stronger effluents of higher organic concentration on storage for a few days may tend to destabilise and be amenable to treatment by the standard chemical pack. A test kit has been producted (called 'Floc-Kit') to test the suitability of any particular effluent before attempting to treat a whole batch. If the test indicates that the effluent is too strong, dilution with plain water is recommended.

In a highly simplified system which must operate with no laboratory back-up a potential problem is how to alert the operator when the first carbon filter cartridge is approaching exhaustion and requires replacement. This is indicated by the inclusion of a pink dye in the treatment pack which begins to emerge in the effluent when the carbon capacity is about 75% exhausted. The intensity of colour increases to deep pink as the carbon approaches complete exhaustion. Some chemically treated effluents are highly coloured and similarly this colour will break through the carbon as exhaustion approaches. All colour is removed when the carbon filters are fully operational so when traces of colour can be detected in the sight-glass situated between the two carbon filters the operator knows that exhaustion of the first filter is approaching. This normally occurs after about 20 batches. If, for any reason, a filter change is delayed, the second carbon filter is in series with the first and will come into action. This also has a capacity of about 20 batches.

The products of the process are cleansed water, dense sludge and exhausted carbon filter cartridges. The water may be recycled for uses such as washing sprayers, containers or machinery or it may be disposed of to sewer or soil with the formal consent of the relevant regulatory authorities as appropriate. The sludge and carbon should be collected by licensed contractors who will use land-fill or incineration for final disposal.

The performance of the process is illustrated in Table 1. A series of independent evaluation trials have been conducted by ADAS and Wessex Region NRA in the UK, Ohio State University in the USA and the Winand Staring Centre at Wageningen in The Netherlands in addition to unpublished work by several commercial users of the process and early work by ICI. Further work is being planned by research workers in other countries which will in due course contribute to the expanding data base. The process has consistently removed more than 99.9% of all pesticides tested and subjected to the best available analytical methods. Residues have frequently been below the limit of detection.

TABLE 1. Performance of the process.

*N.D. = None Detectable

Product	Effluent Initial Loading µg/l(ppb)	Residue in Treated Water µg/l(ppb)	% Reduction	Limit of Detection µg/l(ppb)	Source
atrazine	5,100,000	4.0	>99.9	0.4	USA
atrazine	240,000	N.D.	>99.9	0.06	Netherlands
alachlor	795,000	<4.8	>99.9	0.4	USA
bentazon	480,000	N.D.	>99.9	0.075	Netherlands
permethrin	237,500	N.D.	>99.9	0.4	USA
cypermethrin	50,000	N.D.	>99.9)	)	
pirimicarb	225,000	N.D.	>99.9)	Between)	
carbaryl	225,000	N.D.	>99.9)	0.02 and)	U.K.
dicamba	35,000	N.D.	>99.9)	0.04)	
2,4-D	200,000	N.D.	>99.9)	)	
paraquat	200,000	N.D.	>99.9)		

Earlier results obtained by ICI when analytical limits of detection were less sensitive (of the order of 0.01mg/l) indicate similar trends for a wide range of product active ingredients. These include lindane, DNBP, 2,45-T, captafol, tri-allate, trifluralin, propiconazole, iprodione, di-allate, fluazifop-butyl & MCPA which were often present in the effluent in complex mixtures.

While pesticides for the most part are virtually removed in total, the cleansed water will have a low residual organic carbon content arising from small traces of solvents and surfactants not fully adsorbed onto the carbon. A typical residual total organic carbon (TOC) in the final treated effluent is <50mg/l.

3. THE ALLMAN 'SENTINEL' TREATMENT PLANT.

A family of simple and cost-effective pieces of equipment have been specially developed to use the ICI treatment process. A MKII 1m^3 batch model has recently been introduced with improved ergonomically grouped controls, a low-level chemical loading system, improved handling for the sludge and pumped flow through the filter system. Fig. 2 shows the schematic layout of the 1m^3 plant. Construction is of plastic with a simple steel frame and may be sited outdoors although it is better to house it under cover or in a building. Only a light concrete base is required but this should be bunded to contain any spillages and these should be ducted back to the effluent storage tank. Fig. 3 shows an installation in a farm situation but the unit may equally well be used in factories, laboratories, fruit stores or warehouses which will differ in detail. Most installations use electric motors for pump and agitator drives. For remote locations engine and battery drives are available.

The sludge settlement system is used after every third batch. A secondary flocculation is induced in the sludge tank which is sited under the main tank and the sludge volume is reduced to 20 litres before being passed into the sock filter and allowed to drain. The solids retained in the sock can be stored prior to disposal in a secure bin where further drying will take place until a dry powder state is reached. The liquid separated from the solid sludge in both the sludge tank and the sludge filter is returned to the main tank for retreatment using the main pump.

When flocculation is complete and sludge has settled below the level of the outlet valve in the main tank the clarified liquid is passed through sand and cartridge filters and then pumped through the two carbon modules in series. Flow is restricted to 5 l/min to allow sufficient residence time in the carbon for effective removal of dissolved organic materials. The pumped flow allows the discharged water to be delivered directly into a storage tank if it is to be reused. The process requires about four hours to complete but an operator need only be present during the first stage, when the treatment chemicals are added, and again briefly when the carbon filtration stage is started.

For the treatment of larger volumes of effluent several $1m^3$ plants may be linked together. Alternatively a plant with a single large capacity tank (3 or $5m^3$) with or without appropriately sized carbon modules, is available. For applications at the opposite end of the spectrum such as for laboratories, field trials teams or small industrial users a compact $0.3m^3$ batch model has recently been developed.

Figure 2. The treatment plant.

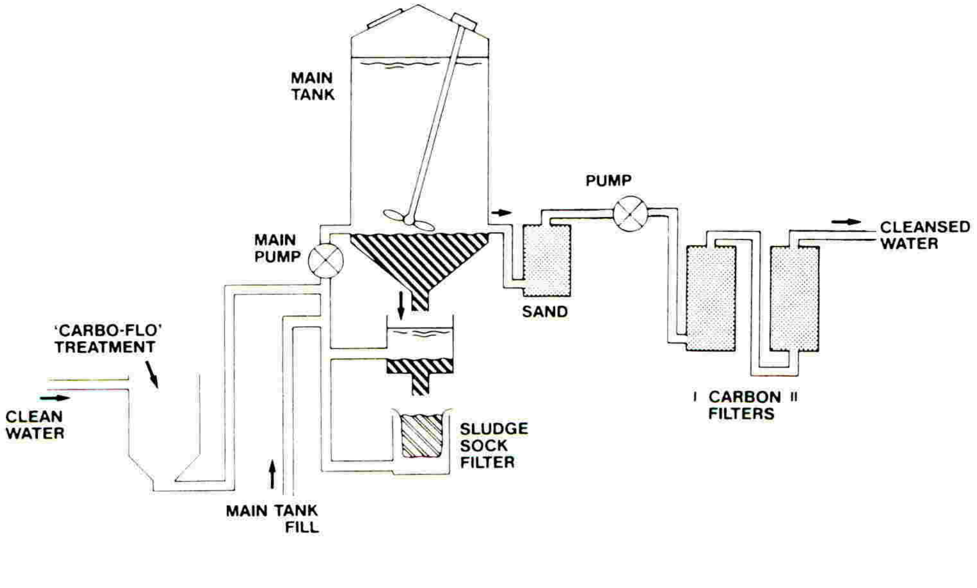
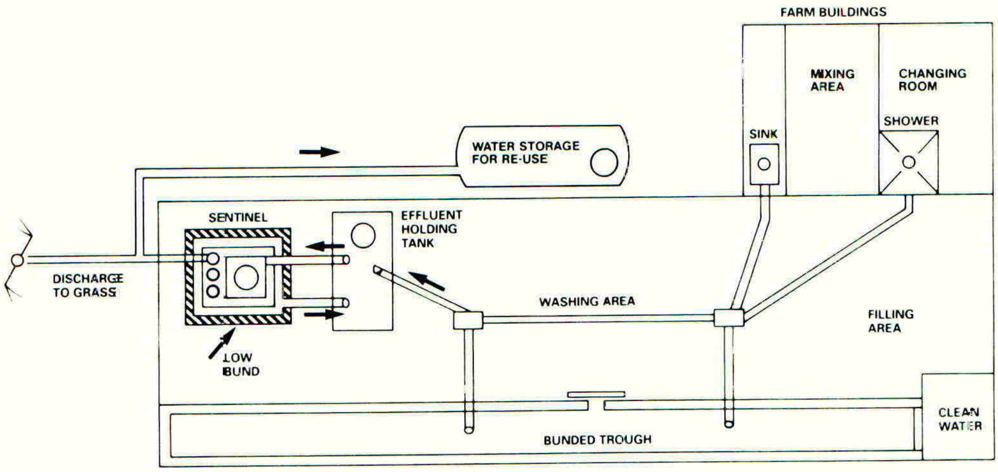


Figure 3. A farm installation.



4. **APPLICATIONS FOR THE PROCESS.**

(a) Agrochemical Manufacture

Effluents arise from all agrochemical manufacturing processes due to the need to frequently clean mixing vessels or other items of process plant. Spillages or surplus liquors have also to be disposed of safely and efficiently. A large formulating plant may need to treat up to 100m^3 per day of effluent containing up to 10 different active ingredients at concentrations of up to 1% in addition to the other agents used in formulation.

It is usual to collect plant effluents in a common sump although where effluent streams are very different in nature a separate small treatment plant for each stream may be worth considering. The common sump provides storage capacity and a means of buffering the changes in composition which frequently occur.

Standard 1m^3 or 5m^3 plants may be suitable for particular installations but the treatment capacity can be modified to suit the needs of the site by linking units together. The working rate can be accelerated by the use of several units working in rotation to give virtually continuous operation and by sizing the carbon and sludge handling capacity to allow a high throughput.

In factory installations the flocculating chemicals will probably be added by automatic dosing equipment under the close supervision of technical staff who will also monitor and modify the conditions if required. The choice of treatment chemicals need not be limited to those in the standard pack as a wider range of flocculants may be used under factory conditions. It is possible to modify the process to handle particularly strong or difficult effluents. Two stage flocculation, pre-treatment to eliminate gross solids or large proportions of oil are likely to be useful in particular circumstances. Where the previous method of bulk effluent disposal was to a licensed contractor there will probably be a considerable cost saving through treatment on-the-spot.

(b) Agrochemical Field Use

Priority is now being given to minimising the quantities of waste water generated. For example, by the use of low volume flushing devices for sprayers and disposal of washings on unsprayed or under-sprayed areas of crop. Nevertheless, waste water with low levels of pesticide is inevitable in any modern crop spraying operation. When sprayers are filled spillages of chemical may occur, tanks may be overfilled or foam overflow. Even if precise quantities of spray have been mixed, unused material is always present in the tank, pump and booms at the end of the spray job and, depending upon the chemical to be applied next, this will have to be disposed of and the machine thoroughly cleansed. On an intensive holding this may be required several times per day. In addition a modern farm may have to dispose of contaminated water from a laboratory, mixing bay or shower.

There are many variations in the pattern of agrochemical use which can result in the need for water treatment. The treatment of washings and unused chemical from arable or horticultural crop spraying and similar uses in research stations or field trials operations are established and well tried applications. The system is also in use for seed treatment wastes and in protected crops, municipal gardens and industrial uses of agrochemicals. Unusual applications which involve the treatment of particularly strong effluents are for bulb dips and post-harvest fruit dips. These may require modifications to the process and should be subjected to laboratory evaluation before adoption. Sheep dips are a potential application but the very high organic loading and large proportion of oil in used dip will require a multi-stage approach and modifications to both the process and the plant. This is an area for future development.

In addition to these largely static uses there are opportunities for contract water cleansing services either by taking the plant to the stored effluent or by bringing the effluent to a central treatment plant. Services of both these types are now available in the UK and several countries are conducting studies which may lead to government-run sevices which could become mandatory.

5. DISCUSSION

At the manufacturing level the agrochemical industry has generally kept pace with new developments and rising standards in environmental protection. But, some past field practices are no longer acceptable to the regulatory authorities or the general public. The industry needs to be sensitive to this change in operating climate. The disposal of waste water is an area which is lagging behind the development of more precise means of chemical pest and weed control and the development of improved chemical storage, handling methods and application techniques.

The relative costs of different methods of disposal are likely to vary widely in different situations. However, treatment on-the-spot reduces the volume and weight of material to be disposed of to specialist contractors so it becomes more easily managed and costs are reduced. The cost of the 'Sentinel' plant will in many cases be about 50% of the total cost of a new installation which includes a collecting tank, pipework, electrical supply and bunded base. In the UK farmers can obtain a grant of up to 50% of the capital cost of a complete approved installation.

Even after more than 20 years experience of operating the process it has not been possible to test all products. Experience has so far failed to produce evidence that any specific or group of agrochemicals cannot be effectively treated.

The rôle of regulatory and enforcement authorities is likely to be crucial in determining the rate of adoption of improved disposal practices in agriculture. Continued satisfactory operating experience with the system and an expanding data-base of independent analytical results are expected to result in a growing level of official support internationally. The guiding philosophy for environmental protection in the UK is based on the best available technology realistically priced for the widest range of users. The system described in the paper was specifically designed to meet this need.

REFERENCES

Hall, F.R.; Downer, R.A.; Chapple, A.C.; Cooper, J.A.; (1990) Preliminary Investigations into the 'Sentinel' Pesticide Waste Management System. Ohio State University, U.S.A. Unpublished report.

Wagemaker, F.H., (1989). Orienterend onderzoek naar de effektiviteit van een kompakte fysisch-chemische zuiveringsunit voor afvalwater verontreinigd met bestrijdingsmiddelen. Rapportage van de werkgroep 'Carbo-Flo'. The Winand Staring Centre, Wageningen, Holland. Ref: 89-064X.

'Carbo-Flo' is a trade mark of Imperial Chemical Industries PLC.
'Sentinel' is a trade mark of E Allman & Co Ltd.

IMPOSING SAFETY BY DESIGN

E. ALI

Nomix-Chipman Ltd, Portland House, Portland Street, Bristol.

R.P. GARNETT

Monsanto plc, Thames Tower, Burleys Way, Leicester.

ABSTRACT

Pesticide legislation has put a considerable onus on the user to be responsible not only for the safe use of a pesticide but also for the wider consequences of its use. Hazards to the user and the environment are reduced by packaging and application systems which minimise the handling of undiluted products, particularly by avoiding measuring and mixing. This paper describes the development of a hand-held sprayer which meets these objectives.

INTRODUCTION

The use and application of pesticides has a high public profile and is subject to great debate in the media. Their use is now highly regulated by the Control of Pesticides Regulations, 1986, which clearly defined the profound responsibilities of the pesticide user:

"Any person who uses a pesticide shall take all reasonable precautions to protect the health of human beings, creatures and plants, to safeguard the environment and, in particular, avoid the pollution of water".

The Control of Substances Hazardous to Health Regulations, 1988, obliges pesticides users to choose the safest product available and to analyse their spraying procedure to minimise exposure:

"So far as is reasonably practical, the prevention or adequate control of exposure of employees to a substance hazardous to health shall be secured by means other than the provision of personal protective equipment".

These regulations and other legislation impinging on pesticides give the pesticide user a daunting task, but he is aided by the "Code of Practice for the Safe Use of Pesticides on Farms and Holdings" (MAFF/HSE, 1990). This guides the user towards process, operational and engineering measures which can be taken to minimise exposure to pesticides of the operator and the wider environment. The pesticide industry is working on these areas to minimise the risk of exposure. For example, there has been great interest in the design of packaging since a National Farmers' Union survey in 1981 revealed serious inadequacies in pack design (NFU, 1981). The transfer of undiluted product from the pack to the sprayer is a major route of operator contamination (Abbott *et al*, 1987) but innovations in design such as a wider diameter neck, together with proper operator training have helped reduce exposure from this source (Gilbert, 1989).

The use of design to help the user is a surprisingly recent idea. The use of design to impose safety on operators using hand-held sprayers during the whole spraying operation is explored in this paper. This approach makes the legislative requirements look less daunting to the user. It does not eliminate the need for operator training, nor replace the thought process encouraged by COSHH, but it does ensure that the requirements are more easily achievable and more likely to be met.

ATTITUDES TO SAFETY

Surprising results were provided by recent market research carried out by Nomix-Chipman into the use of chemical application equipment in the agricultural and consumer sectors.

There was a real awareness of environmental issues amongst amateur gardeners but as individuals they felt that they contributed little towards harming the environment. Consequently, there was little evidence that they were taking any positive action to use pesticides more safely than in the past. There was a need for information and the provision of solutions to the basic problems of using pesticides, such as disposing of excess spray solution. A number of people confessed to pouring unwanted chemical down the garden drain. There were clear signs, however, that given the right spray equipment at the right price, people were likely to foster a more responsible attitude.

In the agricultural industry, the main objectives of the research were to evaluate attitudes to the calibration of boom sprayers, and the accuracy of spray applications. Interviews were held with over 40 farmers in Essex, Lincolnshire and Humberside. Few were taking time to calibrate their spraying equipment. They were relying almost exclusively on their experience, nozzle selection and manufacturers' information, in the belief that they would be within 5% of the recommended application rate. An average farmer, who annually purchases upwards of £130,000 of chemicals, may lose £6,500 from overdosing the chemical by 5%, yet reliance on nozzle selection alone can lead to much greater losses from overdosing by as much as 10-30%. The responses show that calibration equipment is perceived as too expensive, too difficult to understand and too time consuming to use.

There were four clear conclusions from these two groups. These conclusions also apply to industrial and amenity users:

1. Users lacked a real understanding of the safe use of pesticides.
2. Individuals perceive that their own actions have little impact.
3. Pressures of time and money lead to less responsible attitudes to safety.
4. Current packaging and applicator design was poor.

It is this last area that, in our opinion, is the biggest cause for concern. Only by developing and manufacturing better systems will the other three problem areas begin to be overcome. A complete spraying system, simple to operate and incorporating the closed transfer of product to the sprayer with a quick and easy method of calibration, minimises the time and effort involved in spraying. The user is then likely to spray more accurately and safely for reasons of cost and safety. Safety is being imposed on the user.

NOMIX-CHIPMAN APPROACH

The company have aimed for a complete approach to product development, combining the applicator, packaging and formulation.

Nine years development of controlled droplet application, using spinning disc technology, has resulted in an extremely accurate electro-mechanical system. Spinning discs were originally developed for spray application primarily to increase spraying efficiency. They allow much reduced volumes of spray to be applied, minimising the need to carry water, and give considerable control over droplet size and spectra. Spinning disc design improved considerably in the 1970's (Heijne, 1980) and has been further refined in the new system. Two types of spinner are available: a circular toothed spinner for wide spray swaths and a square spinner for treating narrow bands. The spinners are driven by a small electric motor. This is the basis around which a hand-held spray lance has been designed and built, and formulations have been tailored.

The Superpro applicator was launched in April 1989 and embodied many of the innovations that had been developed over the previous years. A range of ready to use oil-based herbicides is available for use at low spray volumes (10-30 l/ha.), compared with the higher spray volumes required for conventionally applied herbicides which are diluted in water. The packaging is a collapsible 5 litre bag in a box, which is carried on the operators' back and delivers the product through to a lightweight but robust hand lance. Electronic control of swath widths and an adjustable pacing device are used in conjunction with a vernier to allow accurate spray control. A novel calibration cup can be used to determine exact flow rates. Rechargeable batteries and a choice of shaft lengths complement the applicator.

Great emphasis is placed on design. Having established the basic engineering principles, products are designed from the "outside in". Almost all the components are custom designed and manufactured, which allows freedom to exploit key areas such as ergonomics, handling and aesthetics. The look of a product is dictated by a diverse range of factors, hence "form follows function". One of the biggest influencing factors is ergonomics, in other words the human interface. Designing hand tools involves a series of compromises: controls should be convenient and simple to operate, weight must be evenly distributed to minimise fatigue and safety parameters have to be met. Durability is essential since applicators can be subject to severe treatment by users, and to extremes of climate. It is generally a balance between material types and design form. The aesthetics of a product are often considered to be of minor importance, but they can convey a sense of quality, durability, and value for money.

CASE STUDY : COMPACT LANCE

The original applicator was conceived for large scale users, but a niche was highlighted for a smaller lightweight machine. The new machine should allow manoeuvrability in difficult areas and would not require the use of a backpack. It could be used around the farm and in the amenity market, by occasional or small users or as a back-up machine to the Superpro for spot treatment.

The new applicator, the Compact™, uses the same spinning disc technology as its predecessor, with the added sophistication of a microchip to control disc speed and calibration functions (*Figure 1*). It is designed to be used with the same pre-mixed, ready to use chemicals, but these are supplied in a unique 750ml cartridge. A 750ml cartridge is equivalent to two full knapsacks containing a total of 30 litres of water-based herbicide. One cartridge of glyphosate will treat a 0.15m swath for nearly 5 kilometres.

Development began in early 1988, and from the outset, the product was conceived as a system. Silhouettes of the applicator and chemical cartridge were drawn together in the original design sketches. The geometry of the lance allows comfortable and accurate handling. The centre of gravity runs through the handle and only moves slightly as the bottle empties, but always maintains a slightly top-heavy feeling. Consequently vertical nodding of the lance head is eliminated during walking, allowing accurate control of spraying height.

Plastics used in sprayers can be subject to a high degree of chemical attack. The new applicators have pioneered the large scale use of the Monsanto plastic Triax®. This is an alloy of nylon and acrylonitrile-butadiene-styrene (ABS). On moulding, the nylon separates and forms an external skin, preventing chemical attack, with the ABS forming the main structure, which is light and robust. More critical components which are constantly in contact with the chemical, such as the valve, are made in acetal.

Controls

The main controls of the lance are situated on a sealed membrane touch-pad just beneath the trigger. A 3-position switch controls the spraying width by changing the rotational speed of the spinning disc, which is driven by a motor housed at the end of the shaft. A microchip maintains the rotation of the spinner at a steady speed compensating for decaying battery voltage to ensure an even spray width. The second switch on the pad is a pacing device which allows control of walking speed. A uniform application rate is ensured by walking in time with the bleeper.

The flow of chemical on to the spinning disc is controlled by a vernier, created between the head cap and the motor housing at the end of the shaft. Rotating the head cap changes the flow according to a scale shown on its perimeter. Having established swath width and walking speed, flow settings can be set by referring to a calibration table. Accurate adjustments, which take into account minor variations in viscosity of the liquid due to temperature, etc. can be achieved by using the calibration cup. This transparent cup clips on to the spray head to form a sealed unit. The pacing device is set to calibration mode and the chemical allowed to run into the cup. Air is exhausted through a venting tube which ensures the system remains sealed at all times. After an automatically determined time, a "bleep" signals the end of calibration and the valve is switched off. The system is then inverted and a scale indicates the volume collected. The chemical can then be safely run back into the handpiece and the test repeated, if necessary, by altering the vernier setting until the desired flow is achieved.

Herbicide Pack

The heart of the system is a revolutionary cartridge which is made by welding two halves of injection-moulded polyethylene, and trapping a preformed internal flexible membrane. This creates two compartments. A "chemical" side which also contains the exit for the chemical and an "air" side which contains a small air vent. This vent allows air to displace the collapsible membrane when the chemical is draining under gravity during use. The inner membrane is formed to fit tightly into one side of the containers. As the cartridge empties, it deforms until it gently flips over to the other side when it is completely empty.

After filling, the cartridges are sealed with a unique two-piece safety valve and cap. This ensures that the valve can only open when securely fitted into the lance. When the cartridge is ejected, the valve shuts instantly and the child-proof cap can be clipped on for extra security during storage.

The development of a manufacturing process was complex. Potential manufacturers felt that the technology required would be too costly and time consuming to develop for a limited market. However, a prototype machine was constructed to preform membranes and weld these in line between the two halves of the body. Progressive development over three years led to high quality bottles with process times approaching those of blow moulding techniques.

Operator Safety

The applicator is designed as an enclosed system, to avoid contact between the operator and the spray liquid. However, once the liquid is atomised, it is again in the open environment. Abbott *et al* (1987) showed that, as all knapsack operators know, walking through the spray is a major source of contamination, particularly of the lower leg. This area of the body should be protected by rubber boots, but reduced contamination is desirable.

A standard technique has been developed for studying operator contamination. Using this method, the contamination arising from the Nomix™ system has been compared with that from a standard knapsack sprayer fitted with a yellow Polyjet deflector nozzle (Merritt, 1989). When fitted with the serrated spinner and held such that the operator walked through the spray swath, the total spray concentration of the lower legs was 87μl. This compared with 916μl when using the knapsack sprayer. The net contamination of active ingredient, in this case glyphosate, was actually higher than from the knapsack, 12mg vs 7mg. However, in normal use, the lance is designed to be sufficiently long that the operator does not walk through the spray. When measurements were made in this situation, in a separate trial using the square spinner, contamination fell sharply to 3.2μl compared to 3880μl from the knapsack. This is equivalent to 0.5mg compared to 28mg of glyphosate. The applicator gave negligible operator contamination.

The operator is also at risk from fine droplets which are displaced from the swath by air movement. The risk of this is lower than with conventional sprayers, as illustrated by the relatively very small quantities displace downwind (Merritt, 1989). At a height of 0.25m, 2m down wind, a total of 0.56μl were collected from the serrated spinner compared to 136μl from the knapsack sprayer. This is equivalent to 0.08mg compared to 1.0mg glyphosate. Using the square spinner, the amount decreased to only 0.05μl, i.e. 0.007mg. The rotary atomisers produced fewer fine droplets, so the spray was less susceptible to displacement.

CONCLUSION

The safety of pesticide application can be significantly improved by applying design processes to equipment development. The Nomix system illustrates this principle applied to hand-held sprayers allowing the user to more easily achieve the safety requirements set by the legislation. The development costs were high, but a commitment to market research established the need for a safer hand-held sprayer, and identified a market of sufficient size to make the project viable. Design Council awards have been presented for the design of both of the lances described in this paper.

The lances, pesticide containers, and the pesticide product range are being actively developed to ensure the continued effective and safe application of a broad range of pesticides.

REFERENCES

Abbott, I.M.; Bonsall, J.L.; Chester, G; Hart, T.B.; Turnbull, G.J. (1987) Worker exposure to a herbicide applied with ground sprayers in the United Kingdom. *American Industrial Hygiene Association Journal*, **48(2)**, 167-175.

Gilbert, A.J. (1989) Reducing operator exposure by the improved design and handling of liquid pesticide containers. *Brighton Crop Protection Conference - Weeds 1989*, **2**, 593-600.

Heijne, C.G. (1980) A review of pesticide application systems. In: *Spraying Systems for the 1980s*, J.O. Walker (Ed.), *BCPC Monograph No. 24*: BCPC Publications, 75-83.

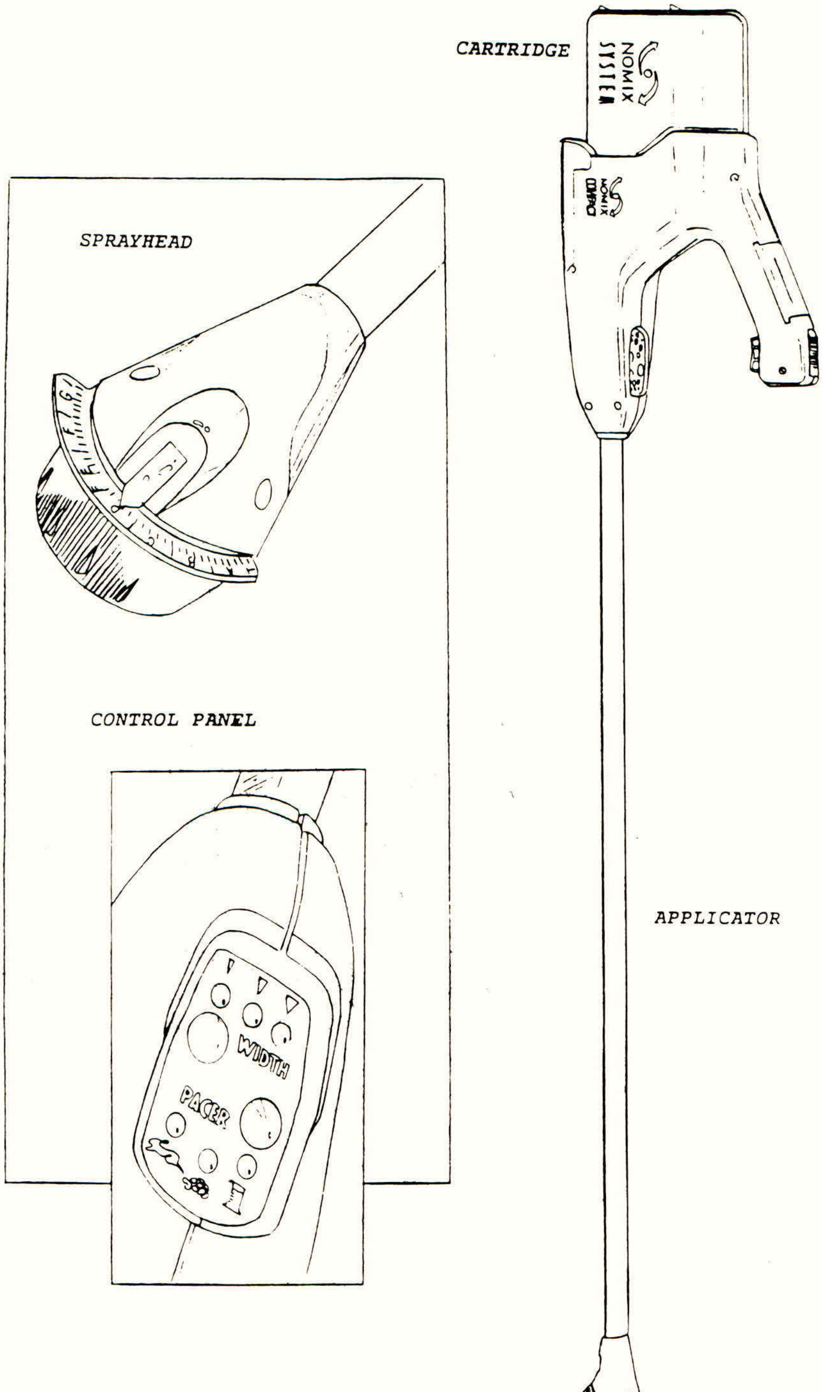
MAFF/HSE (1990) *Pesticides : Code of Practice for the Safe Use of Pesticides on Farms and Holdings*. HMSO Publications.

Merritt, C.R. (1989) Evaluation of operator exposure and spray displacement with hand operated herbicide application systems. *Brighton Crop Protection Conference - Weeds 1989*, **2**, 623-630.

NFU (1981) *Pesticide container design.* National Farmers Union, Agriculture House, Knightsbridge, London SW18 7NJ.

™Trade Marks of Nomix-Chipman Ltd / ® Registered Trade Mark of Monsanto Company.

FIGURE 1. Diagram of the sprayer.



A DIRECT INJECTION SYSTEM FOR PRECISE APPLICATION OF PLANT PROTECTION PRODUCTS

K.-L. NAU, H. RAFFEL

CIBA-GEIGY GmbH, Division Agro, Liebigstraße 51 - 53, 6000 Frankfurt 11

ABSTRACT

Agroinject®, developed by Ciba-Geigy Germany and MSR, is a direct injection system for environmentally safe application of plant protection agents. It puts into practice the concept of direct chemical dosing. Liquid plant protection agents are sucked from the original containers by a precision dosing pump driven by the water stream. The system can apply up to 4 different products simultaneously at doses ranging between 0.05 - 12.0 l/ha. It is therefore capable of applying all modern plant protection products. Further advantages are the ability to spot and the avoidance of residues of pesticides in the tank. The system therefore is from the technical point of view an important component of economically and ecologically optimized integrated plant protection.

INTRODUCTION

The idea of direct injection of plant protection products is to add the concentrated product to the carrier medium just before the spray boom sections and mix and spray them as a homogeneous liquid through the nozzels. In such a system concentrated plant protection agents are carried in a separate vessel or in the original container while the tank of the sprayer is only filled with the carrier medium (usually water). Diagram 1 shows a diagrammatic view of a direct injection system.

The development of systems for direct injection of plant protection products has intensified since the beginning of the eighties, but none of the systems is widely used. Besides material problems this is also due to the difficulties of obtaining accurate dosing. Further problems arise with the wide dosage rates of water and plant protection products and their different chemico-physical properties. A direct dosing system will only be accepted in practice if all the above-mentioned requirements are met.

Until now all systems have been based on pesticide injection by an externally driven dosing pump, usually a peristaltic pump. They require a large control unit, which continuously compensates for changes in application parameters e.g. when the driving speed or the number of spray boom sections is varied, the control unit adjusts the output of dosing pump in order to keep the application rate of pesticide constant. The adjustment of the dosing can result the periods with varying spray fluid concentrations, inevitably resulting in wrong dosage rates. A further disadvantage of these pumps is the fact that only one product per pump can be injected, which means a lack of flexibility in the system.

DESCRIPTION OF THE DIRECT INJECTION SYSTEM

The system was developed by Ciba-Geigy and MSR. A constant concentration of spray fluid is achieved by a precision dosing pump driven by the water flow, such that the dosing of plant protection products is proportional to the volume of the carrier medium displaced. When one application parameter is changed the dose is automatically adapted without delay to the changed conditions, thus keeping the spray fluid concentration at a constant level. Diagram 2 explains the function of the system.

The system was developed under the precondition that it should be easily adaptable to all commonly used field sprayers. A module consisting of presicion dosing pump and mixing chamber is installed between control unit and spray boom selection valves. The construction of the field sprayer must not allow spray liquid to return into the tank. Therefore the control unit must either be connected to a control computer or a constant pressure regulator. For the constant pressure regulator to function correctly, the valves of the spray boom sections have to be pumbed in parallel to the valves of the constant pressure regulator. A direct hose leads from the control unit of the field sprayer to the precision dosing pump, where the concentrated plant protection product is fed from the original container into the carrier medium. Due to the many different kinds of sprayers available, the inlet assembly for the injection module was constructed in such a way that the feed tubes from the original container can be separated from the inlet unit of the precision dosing pump by a connector. Thus the system can be integrated in all commonly used sprayers.

The volume controlled precision dosing pump operates on the principle that all the carrier medium is flowing through the dosing pump, driving an internal dosing system which is able to suck up to four different plant protection products from the original containers at the same time. The pump operates over flows ranging from 6 l/min to 130 l/min thus enabling application volumes of 150 l/ha - 400 l/ha, working widths of 12 - 24 m, and spot treatment. The injected quantities of plant protection products can be continuously adjusted and independently switched on/off by a switch box from the tractor seat. The possibility of sucking plant protection products directly from the original containers makes measuring and pouring of the products superfluous and thus reduces the danger of operator contamination.

With a flow proportional dosing system the required product output is governed by the spray concentration. The concentration of the spray fluid and the position of the regulating sleeve are dependent on the water and product application rates and can be read off a flow diagram.

Diagram 3 shows a flow diagram for the inlet assembly of 0.1 - 1.0 % spray fluid concentration. In order to exactly regulate the inlet assembly, one has to go down from the desired water volume (l/ha) to the intersection point with the product to be applied - in our example it is a product with a dose rate of 1,0 l/ha - . The horizontal line leads over the spray liquid concentration (0.4 %) to the calibration line of the inlet assembly. Going down from this intersection point leads to the position of the regulating sleeve (4.0). Sprayers with computer can be programmed such that they automatically ask for water and product application rate and then show the necessary settings on a display.

By using different dosage assemblies spray concentrations of 0.05 - 0.15 %, 0.1 - 1.0 % and 0.3 - 3.0 % are possible. This covers all water and product application rates commonly used in agriculture. Table 1 shows that by choosing different inlet assemblies and water volumes product application rates are possible from 0.05 l/ha to 12.0 l/ha.

Between the inlet assembly and the original product container a micro switch for the dosage control and a switch over valve for changing from product injection to rinsing procedure are installed. The micro switch gives signals to a control unit during the injection process. If the signal stops, e.g. in case of an empty container, there is both an optical and acoustic signal on the control unit. The concentrated plant protection product is extracted from the container by a suction lance connected via a switch over valve to a hose with a coupling. The switch over valve is connected with the inlet assembly. When the container is empty, the whole system including all product containing parts may be automatically rinsed. Thus it is possible to completely rinse the sprayer in the field at the end of work or if the operation is interrupted, so that it is free of spray fluid residues and a separate cleaning operation is not necessary. This is of particular importance, when changing between different crops and products.

After leaving the precision dosing pump the premixed spray liquid passes into the mixing chamber where the carrier medium and the plant protection products are thoroughly mixed to a homogenous spray liquid. From the mixing chamber the hose leads to the spray boom control valves. Here the spray liquid is distributed to the individual boom sections.

If required, the dosing pump can be by-passed and the sprayer operated conventionally. The spayer is also equipped with a rinsing system to clean empty containers in the field. The rinsings are discharged separately via an electric pump and a separate spray boom.

DESCRIPTION OF TESTS AND RESULTS

The following results are based on laboratory and field trials in 1990. The sprayer was a Jacoby sprayer, type Eurosuper KS 1000 with 5 spray boom sections and a total working width of 12 m. The control and regulator unit was a computer of Müller Elektronik, Type Uni Control. The water flow was regulated by a flow control valve connected to the computer. The direct injection module was integrated between the flow control valve and spray boom regulator. The valves of the spray boom regulator were controlled electromagnetically. The spray boom sections were filled from the end.

Accuracy of spray concentration and dosage, and the behaviour of spray concentration at the beginning and the end of the dosing procedure were tested. Dosage media were water, formulations without active ingredient with different viscosity and density, and plant protection products with different chemico-physical properties.

For the determination of the spray fluid concentration the dosage mediums were mixed with Brillantsulfoflavin (BSF) and analysed by fluorometry. Samples were taken every ten seconds from different nozzles and spray boom sections. The volume of the samples did not exceed 20 ml per sample, in order to exclude possible superimpositions which might occur through a mixing chamber not working correctly. At the same time mixed samples were taken from different nozzles (1 - 2 l per sample) these were also analysed fluorometrically. By weighing the dosage mediums before and after the trials and by determination of the flow volume it was also possible to determine the actual amount of sprayed dosage medium, however, this method of measurement does not give any results on the uniformity of dosing during the trial and thus can only be used as additional confirmation of the trials.

At the start of spraying, first the concentration of the spray liquid has to be built up. This procedure will be repeated whenever the sprayer is rinsed and a new spray is started. The carrier medium in the dosage pump, the mixing chamber and the hoses have to be replaced and the required spray fluid concentration has to be built up. The possibility of injecting products with different application rates as well as products with different chemico-physical properties requires that the process of building up the concentration has to be finished with all media at the same time in order to avoid dosage mistakes. Diagram 4 shows that when 15 litres of water has passed through the pump, the concentration starts to build up. The target concentration is achieved when 35 - 50 l of water have passed. At the same time the checked columns showing the deviation of the single samples of +/- 5 % from the set concentration, reveals a very high dosage exactness, which is independent of medium or volume.

As already mentioned at the beginning, uniform spray liquid concentration during the application is an important factor for the application accuracy. Diagram 5 shows the deviation of the spray liquid from the set concentration in different dosage media und injection rates. The samples taken during the tests only show minor deviations from the target spray liquid concentrations indicating good mixing of carrier medium and product in the mixing chamber. The very good mixing properties have been repeatedly confirmed in all trials and with all tested media, so that the main precondition concerning the application accuracy has been fully met.

In Germany it is current practice with conventional sprayers to dilute the residue remaining in the sprayer with water at a ratio of 1 : 10 and then spray out onto the previously treated area, with this system, the rinsing process of all parts in contact with the spray liquid is started by simply switching into the rinsing cycle.

Diagram 6 shows the rate of reduction of concentration of spray liquid when rinsing. At a discharge of 150 l the product injection was switched to rinsing procedure. The spray liquid which is in the dosing pump, the mixing chamber and the hoses at the moment of switching to "rinse" has to be removed, before the rinsing process can be started. The diagram shows a reduction of concentration about 30 l after switching the inlet assembly to rinse. Thus in practice it is necessary that the rinsing process is started at a certain point before the end of the field and that this spray liquid is applied on the field as well as the rinsing liquid. The great advantage is that at the end of spraying the complete system is free of plant protection product. Conventional systems require a separate cleaning of the tank in addition to the application of the diluted spray liquid.

CONCLUSION

Considering the above-mentioned technical remarks, the systems offers a number of advantages compared with the conventional systems, which can be separate into technical, economic and environmental advantages, as is shown in Table 2.

® = registered trade mark of CIBA-GEIGY AG, Basle, Switzerland

Diagram 1: Diagrammatic view of a direct injection system

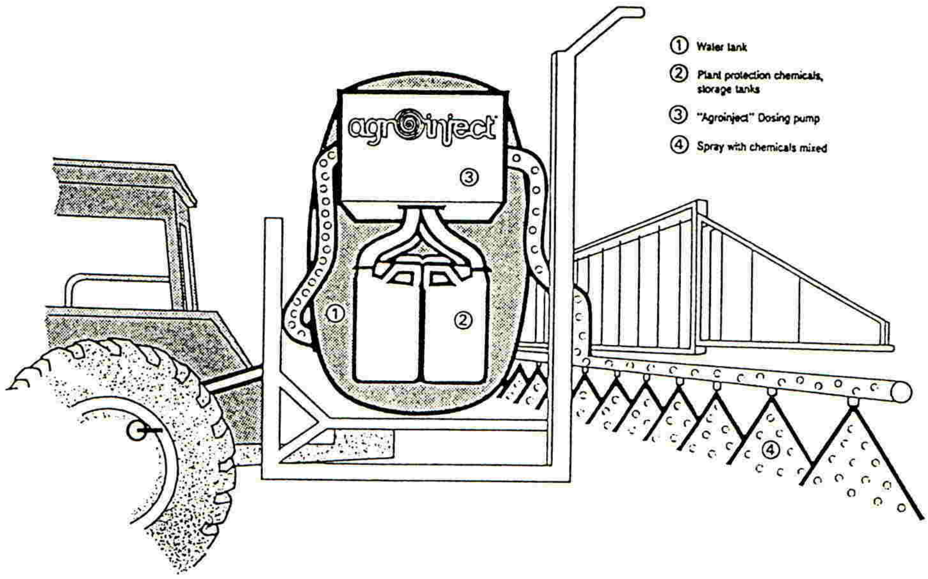


Diagram 2: Diagram of the Function of the direct injection system

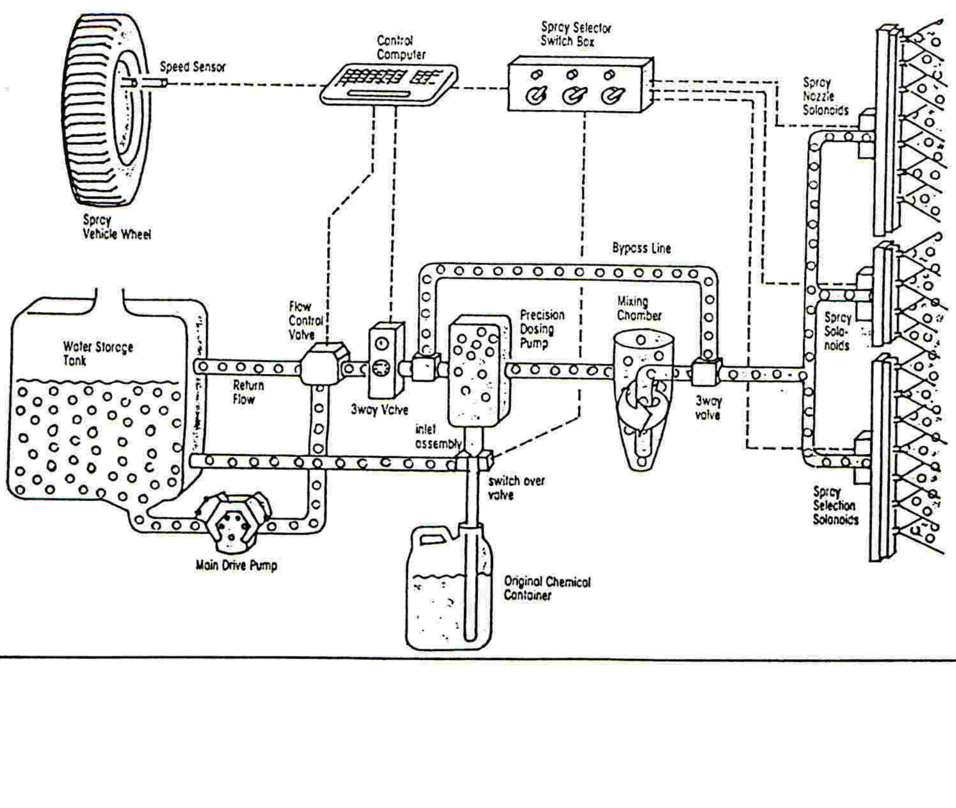


Diagram 3: Flow diagram for inlet assembly of 0,1 - 1,0 % spray liquid concentration

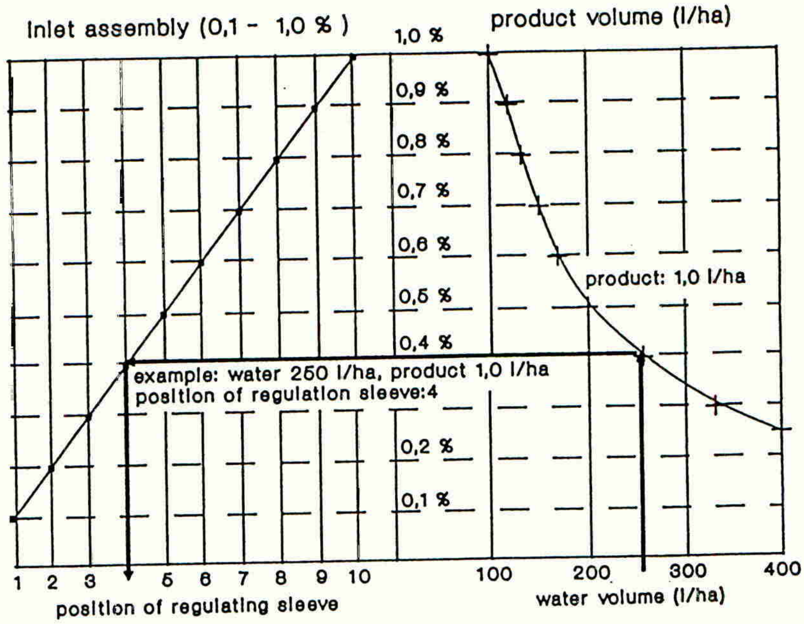


Table 1: Product volumes (l/ha) by using different water volumes and inlet assemblies

Carrier medium (l/ha)	inlet assembly from ..... to ..... % spray liquid concentration		
	0,05 - 0,15	0,1 - 1,0	0,3 - 3,0
	covered product volumes in liters per ha		
100	0,05 - 0,15	0,1 - 1,0	0,3 - 3,0
200	0,1 - 0,3	0,2 - 2,0	0,6 - 6,0
300	0,15 - 0,45	0,3 - 3,0	0,9 - 9,0
400	0,2 - 0,6	0,4 - 4,0	1,2 - 12,0

Diagram 4: Concentration build up by different dosage media and dosage volumes

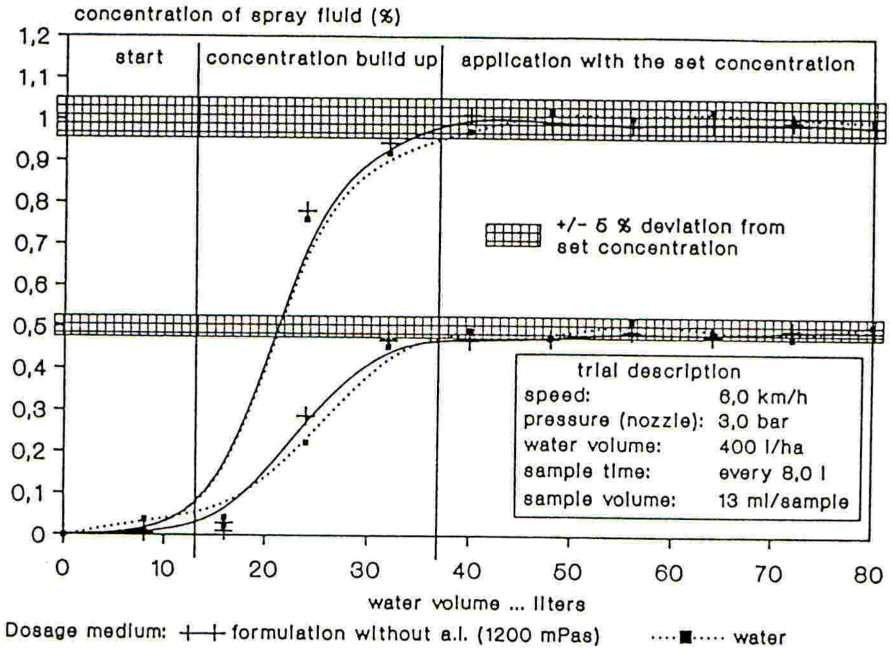


Diagram 5: Deviation of different dosage media and product volumes from the set concentration of spray liquids

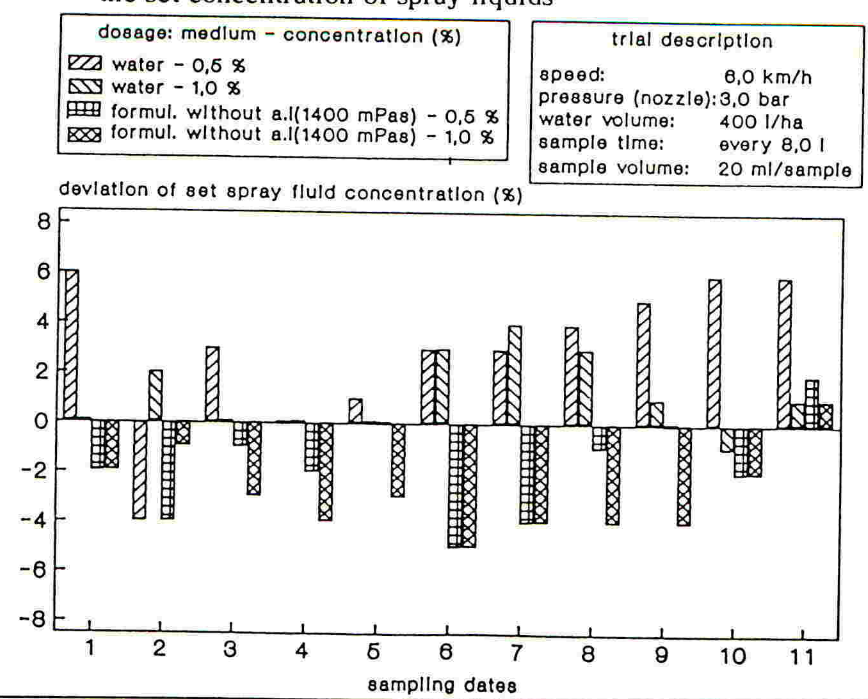


Diagram 6: Reduction of spray liquid concentration after starting the rinsing process

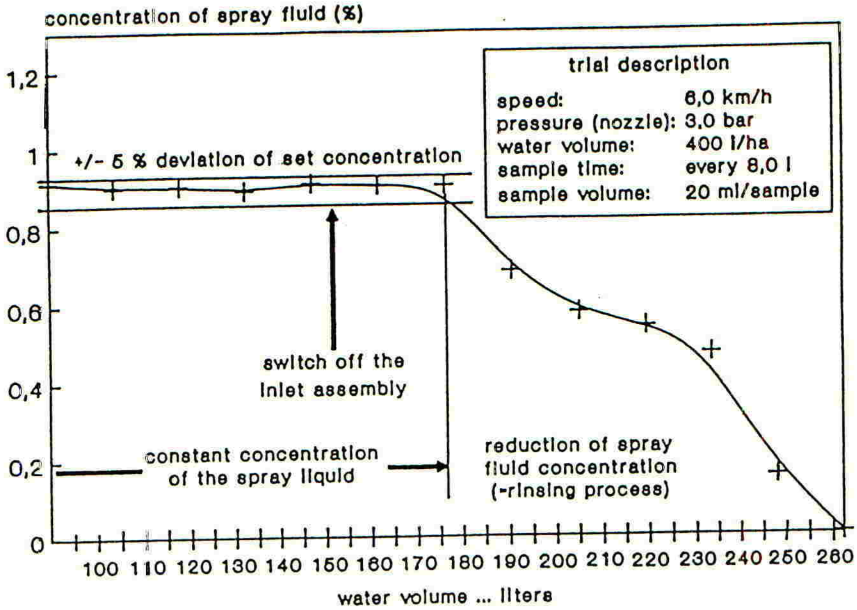


Table 2: Advantages by using the direct injection system

technical advantages	economic advantages	environmental advantages
* constant spray fluid concentration by using a volume controlled dosing pump * all liquid plant protection products can be used * four products can be used simultaneously, independently of the chemico - physical properties * adaptable to all commonly used field sprayers * integral container rinsing system	* saving of working time * saving of plant protection products * field sprayers can be used furthermore for conventionally application	* spot treatment possible * elimination of spray liquid residues * improvement in safety product handling * no waste disposal necessary

AN INNOVATIVE PATENTED CLOSED-HANDLING SYSTEM FOR GRANULAR INSECTICIDES

V.E. BANKS, F.D. TENNE

American Cyanamid Agricultural Research Division, Princeton, New Jersey.

ABSTRACT

In a joint effort American Cyanamid and John Deere developed a patented closed handling system to reduce exposure of farm workers to granular insecticides. This system is currently marketed for use with American Cyanamid's Terbufos 'COUNTER® 15G Systemic Insecticide-Nematicide', Phorate 'THIMET® 20G Soil and Systemic Insecticide' and John Deere's 'MaxEmerge' and 'MaxEmerge 2' planters.

Development of the closed handling system was a response to growing concerns of human exposure to pesticides, pesticide container disposal, and other environmental issues.

The closed handling systems design is a dispensing valve on the returnable container and a receiving valve on the John Deere insecticide hopper lid. When the two valves are coupled, they open automatically to provide a path for the granular insecticide to flow from the returnable container into the John Deere insecticide hopper. When the valves are uncoupled, they close automatically, shutting off flow of the pesticide and preventing any pesticide exposure to the farm worker.

INTRODUCTION

Soil insecticides were first recommended in the United States in 1949 to control Diabrotica species in corn. In the years thereafter, each new product brought improvements in performance, pest spectrum, and safety to humans and the environment. The development of granular formulations of soil insecticides in 1962 was a milestone in worker safety. In 1990 the first innovation in packaging of granular insecticides entered the corn market. American Cyanamid and John Deere developed a unique patented innovation in the packaging of granular insecticides which significantly reduces the farmer's risk of exposure to granular insecticides and addresses container disposal issues.

DEVELOPMENT

American Cyanamid Company, a leading agri-chemical manufacturer, and John Deere & Company, a leading manufacturer of farm equipment, independently sought improvements in worker safety and pesticide container disposal. During formal discussions between the two organizations in 1986 it became apparent that a joint effort was necessary to make a significant change in pesticide handling. Thus, a cooperative effort was initiated to develop the closed handling system.

The following objectives were set at the start of this enterprise:

1. Minimize pesticide exposure to user during refill operation
2. Minimize time needed to refill planters
3. Maximize ease in handling and use
4. Compatibility with John Deere MaxEmerge and MaxEmerge 2 planters
5. Minimize the cost of the pesticide package and planter components

At the onset of this project, existing technologies were examined and evaluated for their compatibility and performance with granular pesticides. Delivery systems, such as those used for liquids and copy machine toner, were evaluated, but were not compatible with granular pesticides.

Since the existing technology was not adaptable to handling granular pesticides, new designs were developed. Prototypes made from these designs were evaluated for compatibility and performance in the laboratory.

After further testing, the prototypes were evaluated in the field in 1989. Farmers who tested the prototypes provided feedback which guided decisions on the design of the final product.

The major components of the closed handling system are a returnable plastic insecticide container and a specially designed lid for the corn planter's insecticide hopper.

OPERATION

The molded plastic returnable insecticide container is equipped with a specially designed dispensing valve constructed of polypropylene plastic.

A specially designed receiving valve is attached to the insecticide hopper lid. The receiving valve is mounted on a heavy duty planter lid equipped with windows for ease of monitoring product flow into the hopper.

The closed handling system containers are packed in specially designed pallets. The pallets are made of polypropylene plastic and hold 27 containers.

To mount the container onto the planter lid, the two valves must come together. The package is turned one quarter turn clockwise to open the valves. The planter valve opens first, then the valve on the insecticide package opens, providing a path for the granular insecticide to flow from the returnable container into the insecticide hopper. When removing the package from the planter, the valves are uncoupled. This closes the valve on the insecticide package first, stopping all flow of the insecticide. The planter valve then closes. The valves close in this order to insure no spillage of the insecticide during the loading operation, thereby virtually eliminating worker exposure. The closed handling system provides the farm worker protection against dust and drift.

After the loading operation, the empty containers are restacked in the pallets and returned to American Cyanamid. Each container is then washed and sterilized to remove any residual Terbufos that may remain. The containers are stored until the time of refilling. During the refilling process each container is tested for leaks or structural damage. The containers are refilled and relabeled for distribution to growers for the next growing season.

Use of returnable containers eliminates the problem of burning or burying of empty pesticide bags. This reduces the risk of accidental poisoning of wildlife or livestock or contamination of water sources by careless or improper bag disposal.

Closed handling system containers can be stored safely. The containers are water proof, puncture-resistant and completely sealed when not engaged with the planter lid valve. This feature reduces the chances of spills, accidental entry into the container when not in use, and other hazards associated with storing open bags.

DISCUSSION

The closed handling system was first introduced into the United States corn market in 1990. American Cyanamid's Terbufos was sold in the closed handling system containers under the trade name of COUNTER LOCK'N LOAD™'. Growers who used the closed handling system were surveyed and they listed the advantages of using the closed handling system in the following order:

1. No exposure to the pesticide
2. Increased safety in handling the pesticide
3. Less exposure to product dust than in bags
4. Convenient to use
5. No smell
6. No bags to dispose of

Use of the closed handling system has steadily increased since its introduction. In 1992, over 40 million pounds of Terbufos will be available in this system.

In 1991 Phorate 'THIMET 20G LOCK'N LOAD™' was made available in the closed handling system.

This patented closed handling system is a significant innovation in packaging of granular insecticides to reduce worker exposure. The first patent covering this innovation issued in the United States in July 1991 and is shared by both American Cyanamid and John Deere. Numerous international patents filings have been made.

The closed handling system will be made available to other manufacturers of granular pesticides and pesticide application equipment. The development of the closed handling system is a major step in providing the farmer with the best safety that is technologically possible while also providing the best tools for crop production.

<u>Trademarks</u>

'MaxEmerge' is a Trademark of John Deere and Company.
'COUNTER' is a Registered Trademark of American Cyanamid Company.
'THIMET' is a Registered Trademark of American Cyanamid Company.
'THIMET 20G Lock'n Load' is a Trademark of American Cyanamid Company.
'COUNTER Lock'n Load' is a Trademark of American Cyanamid Commpany.