HSE CONTRACT RESEARCH REPORT No. 56/1993

AN ERGONOMIC EVALUATION OF AGRICULTURAL CROP SPRAYERS

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HSE commissioned this report on the ergonomics of crop sprayers and the parts of these machines that give rise to hazards and risks.

This document outlines the objectives of the project and describes the approach taken. The recommendations are being used to help develop a harmonised standard for crop sprayers under the Machinery Directive.

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An ergonomic evaluation of agricultural crop sprayers

Volume 1 - Main Report

Contract No. 2351.1/S32.06
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1.0 Background and objectives

1.1 Background

In recent years it has become apparent that exposure of individuals to agricultural pesticides can, in certain circumstances, have detrimental effects upon their health and well being. In view of this it is essential, if the level of risk is to be minimised, that the equipment employed should be of the highest standard and designed in such a way that it not only elicits safe working practices but also does not present any hazards to the user in terms of poor design interface.

Previous research (Feeney 1989, 1990; Weyman 1986; Left 1986) has demonstrated that there exist significant shortfalls in the design of the majority of field crop sprayers in terms of user safety. Feeney, 1990, stated that 27% of the field crop sprayer users surveyed, reported problems regarding leakage, with numerous reports of difficulties with to filing procedures and suspect reliability of control systems. Left, 1986, noted that 20% of the equipment surveyed would not comply with the then current statutory safety regulation.

The most significant problem areas can be seen to pertain to the method used to induce pesticide into the sprayer tank, (specifically where the pesticide is poured from a container); the design of inductive and operational controls; the method of boom control; the method of tank drainage as well as the lack of storage facilities for pesticide and personal protective equipment (P.P.E.).

In 1986, David Left, an Agricultural Inspector for the HSE produced a report entitled “An Evaluation of Safety Features on Agricultural Crop Sprayers” (limited circulation). This report sought to:

(a) study and critically appraise existing and proposed safety features on field crop sprayers

(b) study the attitude of sprayer manufacturers and importers to exposure control safety features on field crop sprayers

(c) make recommendations to reduce the potential risk of the operator contamination associated with pesticide application equipment in agriculture

In addition to the above report, the introduction of the ‘Food and Environmental Protection Act’ (FEPA), 1986, and the ‘Control of Substances Hazardous to Health’ regulations (C.O.S.H.H.), 1988, combined with a rise in the general environmental awareness, there appears to have been
an improvement in the provision of safety features present on many contemporary field crop sprayers. Technology is also changing and new innovations are being introduced.

In the five years which have elapsed since Left's report, it was apparent that there was a need to evaluate any progress that has been made relating to user safety, with specific reference to new sprayer models coming onto the market. The intervening period has seen claims from manufacturers of significant advances in terms of the design of safety features, specifically relating to larger field crop sprayers. It is intended that this report should attempt to evaluate these claims by establishing ergonomic design criteria for each of the relevant design features present in contemporary agricultural field crop sprayers (AFCS's).

The findings of this and any further reports, relating to potential hazards associated with the use of AFCS's, has implications for Committee European de Normalisation (CEN) and the International Standards Organisation (ISO) in the drafting of future safety standards for crop sprayers.

As a result of this Robert Feeney and Associates were invited to put forward a proposal for research to update the work undertaken by Left, 1986.

1.3 Objectives

The objectives of the work, as put forward in the proposal, were as follows:

1) To evaluate developments in the design of agricultural crop sprayers, to determine the effectiveness of engineering controls, warnings and instructions, with specific emphasis being placed upon ergonomic design features likely to affect operator safety.

2) To assess the attitudes of manufacturers in terms of the priority which they attribute to operator safety, with specific reference to the role of ergonomics in design.

3) To make recommendations regarding the development of safety standards and guidelines for manufacturers of large field crop sprayers.

1.4 Definition

Though specific design features may vary according to manufacturer type and model of sprayer, certain fundamental functional principles are common to all.
Thus, for the purpose of this report a field crop sprayer is defined as:

'A tank, a pump and a droplet producing system mounted on wheels, the purpose of which being the application of agricultural pesticides.'

Contemporary field crop sprayers must, then, have a tank into which neat pesticide and water is induced and allowed to diffuse into a solution. The solution is pressurised by a mechanical pump driven from the power take-off shaft of the host vehicle. Pesticide solution is then pumped through an array of nozzles at a predetermined rate, at which point application to crops takes place.

1.5 Classification of agricultural field crop sprayers (AFCS's)

AFCS's may be classified as follows:

a) mounted sprayers (fig. 1) - attached to the rear of a host vehicle via a three point hitch or frame

b) trailed sprayers (fig. 2) - have wheels and are attached via a draw-bar and trailed behind the host vehicle

c) self-propelled sprayers (fig. 3) - consist of either a host vehicle and sprayer built as one unit, or a multi-purpose base vehicle with the facility for sprayer attachment, (commonly termed 'demount' units (fig. 4)).
Fig. 1 above. An example of a mounted sprayer

Fig. 2 above. An example of a trailed sprayer
Fig 3 above. An example of a self propelled sprayer. (Note position of booms across cab).

Fig. 4 below. An example of a demount unit
The following Table summarises the main characteristics of these three types of sprayer:

<table>
<thead>
<tr>
<th>Type of unit</th>
<th>Cost</th>
<th>Weight distributions</th>
<th>Tank capacities</th>
<th>Extras</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounted sprayers</td>
<td>low to mid</td>
<td>compact to tractor on one set of wheels</td>
<td>limited, 200 - 2,000 litres, but usually in the range of 400 - 1,000 litres</td>
<td>none usually</td>
</tr>
<tr>
<td></td>
<td></td>
<td>high weight loading on tractor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>high ground pressure on standard tyres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trailing sprayers</td>
<td>mid to high</td>
<td>tractor and sprayer not a compact unit</td>
<td>large tank capacity 1,200 - 4,800 litres, therefore reduced journeys to fill up, therefore increased spraying rates</td>
<td>can incorporate extra pump for filling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weight shared on more wheels, however sprayer wheels may not follow tractor wheels through crop on side land (some sprayers have a 'tracking' draw bar to decrease wheelings on headlands</td>
<td></td>
<td>room for extra equipment eg. PPE store, clean water supply, induction bowl</td>
</tr>
<tr>
<td>Self propelled and demount units</td>
<td>mid to high</td>
<td>compact unit on one set of wheels</td>
<td>large tank capacity 1,200 - 4,800 litres, therefore reduced journeys to fill up, therefore increased spraying rates</td>
<td>can incorporate extra pump for filling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>room for extra equipment eg. PPE store, clean water supply, induction bowl</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>good visibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>good ergonomic layout</td>
</tr>
</tbody>
</table>

Adapted from H. Catling's lecture notes

2.0 Project outline

The proposal described the following stages for the investigation.

a) information review

b) a market survey of agricultural crop sprayers

c) development of criteria for evaluation

d) identification of the survey plan
e) development of a survey plan
f) survey of manufacturers
g) evaluation of results
h) analysis of results
i) report to the Health and Safety Executive

3.0 Review of available information

3.1 Review of literature

A literature search was undertaken using resources available at the following establishments:

Nottingham University College of Agriculture, Sutton Bonnington;

Loughborough University;

and Birmingham Central Reference Library.

Sales literature and product data sheets were also obtained from all known UK manufacturers and importers of field crop sprayers.

Information which related to current British Standards for field crop sprayers was obtained from the British Standards Institution.

In addition to this the authors were able to draw upon a sizable database, amassed over the last five years, pertaining to the hazards associated with pesticide application, resulting from previous research undertaken by them in this area. The authors also had the benefit of a large amount of empirical data generated in the course of related research projects.
The last decade has seen an increasing amount of interest in the toxic effects of agricultural pesticides. However, the area of safety in relation to equipment design has received rather less attention.

The literature search revealed that comparatively little has been published regarding ergonomic safety issues relating to field crop sprayers, with the notable exception of Left, 1986.

3.2 Consultation with experts

It was envisaged that discussions should take place with HM Agricultural Inspectors and other experts regarding any safety implications for AFCS's, with specific reference to the design features identified during stage 1.

Discussions relating to the safety implications of field crop sprayer use were held with the following experts:

- Dr Paul Miller, AFRC, Silso, Bedfordshire
- Mr Harry Catling, Editor of the ‘Green Book’, Royal Agricultural College, Cirencester
- Dr Brian Wilton, Head of Agriculture and Horticulture, Nottingham University College of Agriculture, Sutton Bonnington
- Keith Barecliff, NPTC examiner, Nottingham University College of Agriculture, Sutton Bonnington

3.3 Consultation with users

Semi-structured interviews took place with a representative sample of users/employers for each of the identified types of AFCS. These interviews revealed a number of practical safety problems associated with these devices.

Several of those interviewed had found the need to have modifications or alterations made to their sprayers in some way, for example:

a) addition of another manufacturer’s P.P.E. store (fig. 5)

b) addition of a clean water supply (fig. 6)

c) additional supports to aid hitching of a mounted sprayer (fig. 7)
d) additional tank access facilities (fig. 8)
e) additional instructions for the use of controls (fig. 9)

The modifications observed were present on sprayers belonging to Agricultural Colleges. The operators at these colleges were aware, due to the NPTC courses undertaken, of the safety features that are required on AFCS's and had adjusted their sprayers to suit the present regulations.

Fig. 5 Addition of PPE store
Fig. 6 left.

Addition of clean water facilities

Fig. 7 below. Added supports to aid hitch and mounted sprayers
Additional methods of accessing tank aperture

Fig. 8 left.

Fig. 9 below
Extra instructions for the use of the controls
4.0 Task analysis and development of criteria for evaluation

4.1 Task analysis

In order to obtain a clear picture of the sequence of events relating to the use of AFCS's, a task analysis was carried out, primarily through a combination of observational techniques and semi-structured interviews with users.

The observations and interviews took place at:

Nottingham University School of Agriculture, Sutton Bonnington
Brooksby Agricultural College
Pershore School of Agriculture
Woodlands Farm, Defford
Royal Agricultural College, Cirencester.

4.2 The operator's tasks

The operator's tasks when spraying can be grouped under the following headings:

- preparation of the sprayer for use
- pesticide application
- cleaning and maintenance

It should be mentioned that several manufacturers have developed a variety of unique innovations relating to the actual application of the pesticide solution. The innovations are primarily designed to decrease drift and maximise crop penetration. Such techniques are not the subject of this report as they primarily relate to application rather than ergonomics design.

4.2.1 Preparation of the sprayer for use

The main safety concern in preparing the sprayer for use relates to the handling of pesticide concentrate. Moving concentrate from stores; releasing of caps / opening of packages, measuring out the required quantity and inducting it into the sprayer are all tasks which pose considerable potential for spillage and the consequential risk of contamination of both the user and the environment. Concentrate is supplied in containers, many of which are poorly designed from the point of view of handling and pouring. Notwithstanding the work of the HSE's Labelling and Container Design Panel (HSE 1991), evidence suggested (Feeney, 1988, 1989; Weyman,
1986) that up until only a few years ago, little effort had been put into the design of containers and packages to avoid splashing and glugging, or to facilitate ease of handling. Only recently have changes appeared which might overcome this problem. Furthermore, it may be argued that they afford a level of protection to the handler which is not tolerated with similarly hazardous substances in other industries.

With conventional sprayer tanks, pesticide concentrate is induced via one or more of the following methods:

a) closed induction system

b) a low level induction bowl

c) a probe which sucks pesticide from the container

d) pouring direct into the top of the tank

e) pumping pre mixed concentrate and diluent

Except for the last method, the pesticide is then combined with water in the sprayer tank to form a solution. From there, the solution is pressurised by means of a pump, which works off the power take-off (PTO) shaft of the host vehicle and is then pumped to the booms where it is applied to the crop through an array of nozzles (fig. 10).

These different methods will be discussed in detail later in the report.

Finally, any container that has been used to hold concentrate must afterwards be thoroughly rinsed out and the rinsing water disposed of, thus posing further potential hazards for the operator.
Fig. 1. Schematic Diagram of a Basic Hydraulic Sprayer.
(Based on H Cattling's Lecture Notes).
Once the concentrate has been diluted in the sprayer and the host vehicle driven to the intended spray site, the boom segments must be positioned and the flow pressure determined. If the operator is able to remain in an enclosed environment to carry out this task i.e. within the cab of the host vehicle, then the potential for contamination is minimised. However, if the controls for pressure setting are situated on the sprayer itself, then the risk to the operator is considerably increased. If the boom segments have to be folded or unfolded manually there are added risks of exertion or snagging.

4.2.2 Pesticide application

In the absence of an air conditioned ‘Q Cab’ the operator is exposed to the inhalation of potentially hazardous fumes when applying pesticide. Even when such a facility is available, if the windows are left open, or if for any reason the operator has to leave the cab, similar risks are involved. Leaving the cab also involves donning and doffing PPE if contact with pesticide either on the sprayer or on the crops is possible. Storage facilities for PPE, if provided, would under such circumstances, be used by the operator.

Other tasks associated with spraying include changing nozzles, clearing blocked nozzles, making further adjustments all of which involve interaction with controls and displays on the sprayer or in the cab.

4.2.3 Cleaning and maintenance

Whilst the prime concern is the potential for contamination of the operator when carrying out the many tasks associated with spraying, there are other hazards to which the operator is exposed. These occur when routine maintenance, adjustment and cleaning take place. The tasks include draining the tank, making adjustments, disassembling and assembling parts etc.. They involve hazards such as: snagging of personal protective equipment (P.P.E.); grazing and entrapment of the hands and fingers; slipping and falling; over exertion etc..
4.3 Results of task analysis

The task analysis provided details of the tasks involved in the use of the range of design features available, with reference to:

a) method of induction, (and implications for handling of concentrates)

b) relative position and direction of functional controls

c) boom handling, opening, folding and related tasks

d) method of nozzle adjustment, replacement and cleaning

e) method of storage for personal protective clothing

f) cleaning and maintenance procedures

g) the role of instructional information and training

h) the role and relative positioning of warning information

The results of this exercise were recorded and subsequently formalised so that each aspect of all the tasks could be studied and its component parts identified. This process was essential to identify specific problem areas and thereby facilitate the design of the check-list for crop sprayer evaluation.

4.4 Criteria for evaluation study

From the foregoing analysis and as a basis for the development of the checklist, the following set of evaluatory criteria was drawn up.

1. All spraying controls should, ideally, be remote from the spraying system (i.e. where hazardous pesticides are present). They must be within the comfortable reach of the operator and be easy to use. Controls should be designed to avoid inadvertent operation and be fail-safe.
2. Instructions should be provided for all aspects of use wherever necessary and should be durable and easy to understand and use.

3. Transfer of hazardous pesticide from the manufacturers (or retailers) containers should be designed to avoid the possibility of operator contact with the hazard. All components involved in the process should be easy to handle, convenient and safe.

4. Arrangements should be made to minimise the possibility of operator contamination through exposure to pesticide from surfaces, components or sprayed crops during the period between leaving the designated (safe) area and returning to it for any of the following operations:
   - nozzle adjustment
   - nozzle clearing
   - induction system adjustment.

5. Access to and from the cab and access to other platforms or parts of the sprayer should be easy and safe and not obstructed by obstacles eg. folded booms.

6. The system should be self cleansing (ie. with clean water).

7. The system should be designed to have the minimum number of parts containing or in contact with hazardous pesticides.

8. The materials used for those parts in contact with hazardous pesticide should be durable, leak proof and not allow contamination of the operator during adjustment, maintenance, service or repair.

9. There should be no disposable contaminated parts resulting from system use.

10. The system should be designed to minimise environmental damage or pollution.

11. The system should be designed to prevent over spraying or under spraying but at the same time give all over (correct) spraying to the required dosage.

12. Ideally the system should cater for the independent application of a number of different fluids at different dosing levels.
13. Displays should be legible, within the comfortable viewing angle of the operator and be easy to understand, use and be durable. Furthermore, they should provide the user with relevant and unambiguous information.

14. The system should be designed to encourage and ensure compliance with the law is both easy and convenient.

5.0 Checklist

5.1 Development of checklist

The checklist used as the prime means of evaluating the crop sprayers was developed using the method described in Section 4.0 above.

5.2 Piloting the checklist

A pilot survey was carried out to assess the checklist for consistency and integrity.

5.2.1 Equipment selected for the pilot study

To pilot the checklist equipment was chosen from examples available at Nottingham College of Agriculture, Sutton Bonnington.

The equipment selected was as follows:

a) a self propelled sprayer (Lely)

b) a tractor mounted sprayer (Allman)

5.2.2 Results of pilot study

The results gained from the pilot survey were recorded, analysed and reviewed, with minor detail revisions being made to phraseology and ordering of questions, wherever appropriate. The complete checklist developed for the survey is shown in Appendix 1.
6.0 Use of checklist to evaluate crop sprayers

6.1 Identification of a survey sample of crop sprayer manufacturers

It was intended that the sample of AFCS's, i.e. mounted, trailed and self propelled, should be selected from those marketed by all known UK manufacturers and importers. The anticipated number in the sample was 25.

The sampling frame for the selection of manufacturers to contact for the evaluation was 'The Green Book', 1989/90, Guardian Publications, 1989. The criteria for selection was those organisations listed in the aforementioned text as UK manufacturers and importers of agricultural field crop sprayers. Additional information was obtained from the HMAI at Bootle and Dr Paul Miller, AFRC, Silsoe. Bedfordshire.

6.2 Manufacturers selected for visits

1) Moteska Sprayers
2) Hardi
3) Knight Farm Machinery
4) Schering Agriculture
5) Spraycare
6) Sands Agricultural Machinery
7) Berthoud
8) Technoma
9) E. Allman
10) A&J Lancaster
21) Team Sprayers
11) Ferrag
12) Hightcoute (Chaviot)
13) Bilericay Farm Services
14) RJ Bateman Engineering
15) Handbury Machine Services
16) Lely UK
17) Gem Sprayers
18) Brit Ag Industries
19) Willmott C&G (AMC)
20) Evard UK
22) Cleanacres Machinery.

For the purposes of evaluating closed systems the advice obtained from those experts interviewed and from the HMAI was taken to provide information relating to known manufacturers. This produced the following list of closed system manufacturers or distributors:

Handbury
AFRC
Agrifutura
6.3 Procedure

It was intended that most of the manufacturers and importers identified would be visited by the researchers.

It was also anticipated that the evaluation of machinery would largely depend upon the cooperation of manufacturers and importers. The strategy adopted for the proposed visits was as follows:

a) establish contact with those manufacturers and importers who were identified as a result of the sampling

b) arrange visits

c) evaluate sprayer models marketed using the check list.

7.0 Results and analysis

7.1 Sample

The sampling method used appeared to be generally satisfactory in that 22 of the 25 manufacturers identified were successfully visited and assessed. The majority of the manufacturers were willing to cooperate by taking part in the survey, there were however one or two exceptions who expressed particularly negative views. In those instances where producers were distributing "badge engineered" products, visits were not undertaken since these could be evaluated at source.

The results given here relate solely to those sprayers which incorporate traditional methods of pesticide induction. A few manufacturers have, or are contemplating the introduction of new methods involving 'direct injection' or 'closed system' induction methods. These were also evaluated and are dealt with separately in Appendices 3 and 4.
7.2 Induction of pesticide

7.2.1 Low level induction bowl

As stated earlier the induction process can be seen as a major source of contamination risk. Typically, the systems examined involved the operator gaining access to the induction bowl, which in many instances posed hazards in itself - particularly if located directly underneath folded booms, and then manually pouring the pesticide, from a very basic plastic container, into the bowl with the attendant risks of spillage, splashing, and handling wet items and components.*

In general terms, where manufacturers provided induction bowls, little difference was found in their design concept. They were constructed in either plastic, fibre glass or stainless steel, some had hinged lids, some lift-off lids and all with one exception had a flushing mechanism. Few of the manufacturers provided induction bowls with an aperture greater than 24cm, as laid down in the ergonomic criteria present in the check-list (see Appendix 1).

Their design was basically a funnel mechanism with an aperture at the top and various controls to allow the concentrate to be diluted plus a simple flushing mechanism to wash the bowl out with either clean water or (partly) diluted, pesticide solution. The location of the bowl and the various controls and features which needed to be handled was largely dictated by technical considerations rather than the requirements of the operator. Thus, in general terms, the level of safety afforded to the operator was largely incidental rather than a priority of design.

Whilst induction bowls were present, as standard, for all but one of the self-propelled (n = 14) and all but one of the trailed (n = 14) sprayers investigated, it was only standard with 8 of the mounted sprayers (n = 25). None of the manufacturers/importers sampled were prepared to admit that an induction bowl was not available as an optional extra, however many pointed out that it was not practical to attach one to sprayers at the lower price end of the market, where manual induction was more common; due to the proportional rise in cost.

*The poor design of both AFCS hardware and pesticide containers are primary contingencies which contribute to the non-wearing of legally prescribed levels of PPE, particularly gloves, respirators and visors and goggles. Due to this often sub-optimal interaction between PPE and the technology, many tasks are rendered difficult and in certain instances impossible when wearing appropriate PPE.
The induction bowls were assessed in terms of:

- The location of the bowl on the sprayer and the ease of access for the operator
- The shape and size of the bowl aperture and the ease with which the lid could be opened and concentrate admitted.
- The location and design of the water flushing controls and the ease with which they could be reached and used.
- The effectiveness of the warnings and instructions.

The location of the induction bowl was consistently poor in terms of ease of access, across all types and models of sprayers, with only one or two isolated examples of acceptable solutions.

eg: Ferrag, Evrard M/Beam, Team Custom, Allman 1500, Hardi SP.

The most common problem was the siting of the induction bowl beneath folded booms, where dripping nozzles could potentially pose a serious risk of contamination, especially if the sprayer tank is being refilled immediately after spraying. In one or two cases this had apparently been overcome. eg: folding of booms such that the nozzles face upwards.

On some sprayers, the siting of the induction bowl resulted in the lid of the bowl being obstructed during opening. If the lid is not fully openable, or retainable, there is the possibility of it accidentally closing whilst pesticide concentrate is being induced, thereby increasing the risk of spillage or injury or both. In certain instances, the booms were positioned so close to the bowl as to physically hinder easy pouring of the pesticide concentrate into the bowl. The most notable examples of this related to manufacturer 3’s tractor mounted sprayers (fig. 11).

Quality of access to induction bowls varied considerably and was not significantly better on more expensive sprayers than on the cheaper ones. The main access problems appeared in connection with those induction bowls that needed to be released from a storage position and swung into place for access, and replaced to the storage position following use. Of the two tasks involved here, releasing the bowl was generally the easier, though not always, typically requiring one hand to release the securing mechanism and the other to lower the bowl. Replacement of the bowl, however, in several instances required a large degree of force to be applied to replace the bowl in its storage position.
Those induction bowls which were rated as having 'easy' access were either positioned away from booms or had the facility for positioning away from potential boom hazards, (typically swinging outwards).

There was a high degree of variance between induction bowls in terms of the ease with which lids could be opened and closed.

Fig 11 left
An example of a boom hazard whilst using low-level induction bowl (hinged lid).
Methods of removal and replacement of lids of the bowls were as follows:

a) **Screw top lids** (eg. manufacturer 1), these had moulded handles on the lid which required two hands to undo. The use of two hands means that the pesticide concentrate must be set down whilst opening the unit. Furthermore, there were no chains or retaining straps present to secure the lid, which increases the risk of loss, damage or possible contamination. Typically, the use of a plastic screw threads for such a large diameter meant that the lids were often difficult to secure and were easily 'cross-threaded'. Manufacturer 1's induction bowls, for example, also had apertures that were too small for safe pouring (diameter of 19.5cm) which could result in splashing and/or spillage occurring if the pesticide concentrate was not handled carefully.

b) **Lift off lids** (eg. manufacturer 4), these require a hand placed on either side of the lid, which is then lifted off completely. Replacement of the lid was the reverse process. The necessity of using two hands on the lid has the same implications as outlined above. The apertures of these bowls were oblong in shape measuring 32.5 x 16.5cm. With such a narrow aperture, this increases the likelihood of splashing and/or spillage occurring.

c) **Hinged lids** (eg. manufacturers 2, 3 and 7), these lids were the easiest to remove and replace requiring the use of one hand only. Lids were unfastened and swung up out of the way. On completion of the induction process the lids were swung down and refastened.
The apertures of these bowls were also of sufficient dimensions to allow easy induction of the pesticide concentrate with less possibility of spillage occurring.

The relevant dimensions were as follows:

Manufacturer 3 (oblong bowl) - aperture: 43 x 33 cm

Manufacturer 2 (square bowl) - aperture: 43 x 43 cm

Manufacturer 7 (square bowl) - aperture: 31 x 31 cm.

Comment

The worst example of an induction bowl in terms of ease of use was that of manufacturer 5. This lid was fitted in a "snap-fit" manner (fig. 12, p 35). Opening required two hands (with the implications as outlined in a) and b) above and necessitated a great deal of physical effort. Closing the bowl was found to be impossible when assessed. Once opened the aperture was adequate for the task with an oval orifice with dimensions of 39 x 30 cm. Fundamentally, this bowl was of a very cheap and crude design.

Manufacturer 6's induction bowls had no lid present, when the bowls were taken from the storage position, the aperture was automatically exposed. When the bowls were stored following use, moving the bowl into the storage position effectively sealed it. The aperture to the bowls were oblong with dimensions of 46 x 38 cm.

Although a water supply for flushing the induction bowls was provided as standard on all of the self propelled and nearly all of the trailed sprayers this was true for only 5 of the 25 mounted sprayers. Where flushing water was available however, the location of the operating valve was often poor necessitating awkward reach by the operator. The controls, which were very similar for all sprayers, in most cases lacked positive stops and the status of the valve was rarely apparent. An example of exceptions to this were models by manufacturer 7 (demount unit) and manufacturer 5.

Instructions and warnings relating to appropriate operation of the water supply valves were universally poor. To understand the correct operation of the different valves, a prior knowledge of
the circuitry was required. Instructions were provided by the use of moulded text on the valve itself. This was difficult to read due to the fact that it was not easily visible against the background.

7.2.2 Probe

The breakdown, by manufacturer, for provision of a probe for induction of pesticide was as follows:

- Standard - 6
- Optional - 14
- Not available - 3
- Not known - 1

Note: It should be noted that while the majority of manufacturers still offered a probe, many said that they viewed such devices as largely superseded by alternative methods of induction, specifically the induction bowl.

The purpose of a probe is to allow the concentrate to be sucked directly out of the container. Control is by means of a valve at the top of the probe. A potential advantage of the probe is that induction can take place away from the booms and thereby reduce the risk of operator contamination. The problem with most probes is that of rinsing. Whilst this may be possible by passing rinsing water down the probe tube, the outside of the tube would, in almost all instances, retain an amount of residue.

Induction probes were assessed in terms of:

- the location and ease of use of the probe
- the ease of use of the control valve
- the use of any cleaning facilities
- the effectiveness of the warnings and instructions.

Probes were provided as standard fitment with 6 of the 25 mounted sprayers, 4 of the 13 trailed and with 4 of the 14 self propelled. In 21 out of 25 cases where an induction probe was not provided as standard, they were cited as 'optional extras'.
In theory, the provision of a probe makes it possible in most of those evaluated to allow movement away from the area under the booms and thereby reduce the probability of contamination from the nozzles. However, the probe in most cases was stored in a position which necessitated the operator to use it under the boom.

All of the probes investigated had a simple control valve operated with the which hand was not holding the probe. The valve did not have positive stops and it was therefore difficult for the operator to know the status of the valve.

In no cases were effective cleaning facilities provided for those probes evaluated, and unless the operator took care to place the probe in a container of water, then effective cleaning would not take place. One manufacturer provided a facility to pump water through the probe after use but this did not clean the outside of the probe and relied on clean water being available.

As with the controls for the induction bowl warnings were invariably absent and instructions were of the moulded text variety indicating the direction of movement for on and off, and were rated poor in terms of legibility.

of those which were evaluated (4) the storage position was mostly rated 'very good'

of those which were evaluated (4) the ease of use was all rated 'bad'

of those which were evaluated (4) the instructions were all rated as 'bad'.

7.2.3 Induction by pouring into the tank

Assessment of this form of induction was in terms of:

- ease of gaining access to the aperture at the top of the tank

- ease with which the tank lid could be opened and the concentrate poured.

Manual induction was required on all those sprayers for which an induction bowl or probe was not standard, unless they were purchases as optional extras.
Generally, it was considered that none of the manual induction AFCS’s evaluated provided a safe method of induction.

In terms of ease of use, of the total assessed (n=17) the following ratings were made: - (n=17) - very bad (5), bad (4), adequate (4), good (3), very good (1)

**Comment**

It is felt that the manual method of induction of pesticide is inherently unsafe in terms of the considerable risk potential for operator contamination. Facilities for manual induction were particularly poor for mounted sprayers, where platforms were generally absent or insufficient for their intended use.

### 7.2.4 Provision of container washing facilities

The purpose of a container washer facility is to cleanse the pesticide container thoroughly to minimise the potential for contamination of both the user and the environment.

Container washers were assessed in terms of:

- ease of use

- position relative to other hazards

The incidence of container washing facilities was as follows:

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>O/E</th>
<th>N/A</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounted</td>
<td>9</td>
<td>4</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>Trailed</td>
<td>7</td>
<td>0</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Demount/Self propelled</td>
<td>14</td>
<td>1</td>
<td>4</td>
<td>19</td>
</tr>
</tbody>
</table>

(O/E - optional extra, N/A - not applicable)

The provision of a container rinsing facility is a high priority if the risk of contamination is to be minimised. Such a facility was, generally, only provided where an induction bowl was standard, and tended to take the form of either a manual rinsing facility (usually a hose attachment to the side of the bowl) or an automatic facility where the pesticide container was held inverted over a nozzle in the centre of the induction bowl. Operation of the flushing facility was achieved by
pressing down on the container which activated the nozzle to rinse out the residue from the container and allowing drainage into the bowl. All the self propelled sprayers had an automatic container washing facility, except one where no container washing facility was provided.

With respect to ease of use, of those present, (11), one was rated 'very good' and all others 'good'.

7.3 Sprayer controls

The controls referred to in this section relate to those which are used for opening and closing the booms and controlling flow to boom sections.

The controls for the sprayers were assessed with regard to:

- the location and ease of use of the controls
- their safety in use
- the conformity of the controls to recognise convention and the representation of each controls function.

The breakdown by type of sprayer for the evaluation of controls was as follows:

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>In cab</th>
<th>Outside cab</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mounted</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>boom segments</td>
<td>25</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>boom up/down</td>
<td>20</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>pressure control</td>
<td>25</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td><strong>Trailed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>boom segments</td>
<td>13</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>boom up/down</td>
<td>13</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>pressure control</td>
<td>11</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td><strong>Demount/self propelled</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>boom segment</td>
<td>18</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>boom up/down</td>
<td>18</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>pressure control</td>
<td>18</td>
<td>16</td>
<td>2</td>
</tr>
</tbody>
</table>

Invariably smaller mounted sprayers had controls on the sprayer itself, whilst self propelled demount units, and many larger mounted and trailed sprayers were designed to be used in
conjunction with in cab controls. Obviously in cab controls can be operated in a much safer environment away from the potential hazards associated with spray mist and crops, particularly if the cab air is filtered.

Typically, sprayer flow controls positioned on the sprayer itself were of a very standardised type, were relatively easy to use and conformed to recognised convention i.e. movement upwards opened the valve, whilst movement downwards shut off the flow.

Boom, controls within the cab and those on the sprayer were relatively easy to use but their positioning could often have been improved.

Representation of the controls was reasonable and in most instances in the form of decals mounted adjacent to the controls. However, this was not consistently maintained and in some cases the decals were small and confusing and in other cases, did not represent the actual controls used. Furthermore, the quality of some decals was rather suspect with widespread use of poor quality materials. The sight of peeling decals was found to be commonplace even though the machinery assessed was almost exclusively new and unused.

7.4 Boom geometry

The boom geometry was assessed in terms of:

- storage position
- height reached when opening or closing (risk of hitting overhead lines)
- position of nozzles in relation to the operator
- ease of opening and closing manually operated booms
- retaining devices to stop opening in transit
- adequacy of warnings and instructions.

As stated earlier, movements of the boom were controlled either by manual handling or by hydraulic power using remote control. The manually controlled booms, fitted exclusively to smaller mounted sprayers, generally folded at the back of the sprayer and each segment was of a relatively small size.

All of the remote controlled booms sampled were stored folded around the sides of the sprayer. This, in numerous instances, caused problems in that the booms obstructed entry and exit to the cab. Furthermore, booms were generally positioned such that the nozzles were above the area in
which the operator carried out routine activities such as the induction of pesticide concentrate, hand washing, and tank drainage etc.

Fully remote control booms were most commonly encountered with larger sprayers and were universal for those self propelled/demountable and trailed sprayers sampled.

All the self propelled/demountable and trailed sprayers sampled had fully remote controlled booms.

The height reached when opening and folding the booms, largely depended upon the plane in which the booms moved and on the length of the different segments. Only booms with long segments opening and closing in the vertical plane ran the risk of touching overhead power lines. Of all the sprayers sampled, 4 with ‘up and over’ type booms were assessed as likely to touch power lines, two of these were trailed one was self propelled and one was a mounted sprayer. It is recognised however that powerline height varies according to different areas and safe opening height needs to be assessed in the light of local conditions.

The position of the nozzles in relation to the operator when getting in and out of the cab and when carrying out activities such as induction and manual boom handling was critical. The majority of the sprayers had booms which were stored in a position which created a potential risk for contamination of the operator in one of the ways described above. Whilst it is logical to store the booms parallel to the centre line of the sprayer, typically, no provision was made for a protective barrier between the nozzles and the area beneath them.

The evaluation of ease of opening and closing of booms referred solely to those booms which were manually operated. Generally, manually operated booms that were no greater than 12 metres in length were stored folded across the back of the sprayer. The opening task normally involved releasing the retaining mechanism which held the booms in position, usually by the removal of a pin or pins and turning a handle which moved the booms upwards and downwards by means of a Bowden cable. The booms were closed by the reverse procedure.

The booms were closed by means of a spring loaded mechanism. This meant that in many instances considerable physical effort was required and there was a potential for injury to the hands or arms through pinching. However, several manufacturers had attempted to guard these, but in many instances, not successfully.
The majority of manual booms had some form of physical hazard associated with their use and were typically of rather crude design. One particular boom, present on several of the smaller tractor mounted sprayers produced by manufacturer 5, were particularly poor in terms of the ease of use of the boom securing mechanism.

In general terms the manual booms assessed were relatively easy to open and close with the exception stated.

7.5 Spraying equipment

The spraying equipment assessed included the type of nozzle used, access to the main pump for the purposes of maintenance and the type of hose clip used and whether or not it was an easily replaceable item.

Nozzles present a hazard as they may drip and expose the operator to risk or, if they need to be changed for different spraying operations, again the operator may be at risk when handling them.

Anti-drip nozzles are now commonplace and flexibility in providing different spraying patterns can be achieved by using swivelling heads or dual boom systems. It should be noted that several manufacturers stated that they had ceased to fit swivelling head nozzles due to problems associated with leakage.

All except one of the sprayers assessed had nozzles of the diaphragm check valve (DCV) variety which were also anti drip and with a snap fit holder. The one exception used a screw on type holder.

The pumps of 6 out of 24 manufacturers machines sampled would be difficult to access for the purpose of maintenance, the remainder were considered to be adequate in terms of ease of access.

Tractor mounted sprayers were rated as providing the most difficulty in gaining access to the pump with 11 out of the 25 pumps being assessed as difficult, or very difficult, to access. One of the trailed sprayers also had a pump which was rated as difficult to gain access to.
Jubilee type hose clips are considered to be more desirable as they are easier to replace and maintain than the crimped type which require a special tool. The vast majority of the sprayers sampled had predominantly ‘Jubilee’ type hose clips. While some manufacturers used a mixture of ‘Jubilee’ and crimped type clips, manufacturer 2 was the only one sampled which used exclusively crimped type hose clips.

7.6 The cab environment (self propelled and demount units)

A well designed cab for the sprayer power unit is probably one of the most significant ways of reducing the potential for risk to the operator when spraying in that, if effectively filtered and sealed, it affords the user high level of protection from spray drift.

In addition to the possibility of an enclosed environment providing protection when spraying, the presence of controls and displays in the cab, rather than outside, which are used for setting up and closing down the sprayer system, will reduce the potential risk of contamination.

The protection can be further enhanced by the provision of an air filtration and air conditioning system within the cab. Carrying out spraying operations from within the cab, requires that there is good all round visibility from within the cab, good access to and egress from the cab and the provision of clear and appropriate warnings and instructions.

Typically, effective air filtration equipment is fitted to large self propelled sprayers and demount units, and commonly not available on smaller types such as low ground pressure vehicles. Its presence under all other conditions, specifically mounted and trailed sprayers, is principally dependent upon the choice of host vehicle.

The cabs for self-propelled sprayers and demount units were assessed in terms of:

- whether an appropriate air filtration system was provided (ref. HSE Guidance Note PM 74)

- whether air conditioning was provided

- visibility from the cab
• access to and egress from the cab

• the adequacy of the warnings and instructions.

Of the self propelled sprayers assessed, the majority had appropriate air filtration and air conditioning fitted as standard or offered as optional equipment.

In almost all cases evaluated visibility from the cab was rated as good. There was, however, considerable variation in the quality of controls both in terms of the positioning and type of switchgear/representations used.

7.7 Ease of use of tank features

The provision of a drain facility on the tank is necessary to enable the tank to be drained in order that it can be thoroughly cleansed before its next use.

Access to the drain facility should ideally be easy and convenient and should pose no risk of hazard either through difficulty of access or through possible contamination when draining.

The tank should also provide an easily visible indication of the level of contents.

The presence of baffles within the tank avoid the possibility of liquid moving within the tank and creating instability in the sprayer vehicle.

The drainage of the tank was assessed in terms of:

• location of the drain tap and the drain tap control

• ease of use of the drain tap mechanism

• the adequacy of warnings and instructions

Generally, the location and method of operating the tank drainage system was rated as 'poor'. Typically, the operator was required to reach or clamber under the tank and release the drain mechanism, thereby increasing the potential risk of contamination as the fluid poured out.
Two exceptions to this were manufacturer 2 and 10. This manufacturer's sprayers generally provided remote tank drainage by means of a shaft which went vertically through the centre of the tank and could be operated from the top of the tank, eliminating the possibility of contamination. It is perhaps worth noting that there was anecdotal evidence that this type of drainage system did not always work effectively. This design feature was not present on those models in the lower price range(s). Manufacturer 2 provided a remote controlled drain tap on one of their trailed sprayers but not on other models.

The ease of use of the drain mechanism was assessed to be adequate, excluding the problems associated with gaining access as described previously.

Manufacturer 5, provided no drainage facility for at least 2 of their sprayers.

Warnings and instructions relating to tank drainage were only found to be present on 1 manufacturers trailed sprayers (manufacturer 2). In terms of ease of interpretation and relative position, these were deemed as 'adequate'.

The sprayer tank contents gauge was assessed in terms of:

- readability of the gauge
- ease of interpretation of the gauge

6 of the contents gauges out of the 57 sprayers sampled were rated poor or very poor in terms of their legibility and 11 were considered difficult to interpret. In most instances these two difficulties occurred with the same sprayer.

**Legibility:**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>No. rated 'poor'/'v.poor'</th>
</tr>
</thead>
<tbody>
<tr>
<td>mounted</td>
<td>25</td>
<td>7 (28%)</td>
</tr>
<tr>
<td>trailed</td>
<td>13</td>
<td>2 (15%)</td>
</tr>
<tr>
<td>self propelled/demount</td>
<td>19</td>
<td>3 (16%)</td>
</tr>
<tr>
<td>not known</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Ease of interpretation:

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>No. rated 'poor'/V.poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>mounted</td>
<td>25</td>
<td>4 (16%)</td>
</tr>
<tr>
<td>trailed</td>
<td>13</td>
<td>4 (31%)</td>
</tr>
<tr>
<td>self propelled/demount</td>
<td>19</td>
<td>3 (16%)</td>
</tr>
</tbody>
</table>

The types of contents gauges provided consisted either of moulded text on the side of the tank; a decal attached to the outside surface of the tank or an engraved plaque, the latter being by far the most durable.

In the case of moulded text, the ease of interpreting the level of solution in the tank relied on the degree of translucency of the plastic material of the tank. Almost all other scales consisted of a clear tube mounted next to a scale, which was much easier to read and interpret. However in a number of cases the decal was not easy to read.

Baffles were in general only present on the sprayers with tank sizes of 1500 litres or above. Six out of the 13 sprayers with 1500 litres or above capacity had baffles present in their tanks.

7.8 Access facilities to the sprayer tank

Although manual pouring of pesticide into a sprayer tank should be avoided, access is often needed for other purposes eg. maintenance. In such cases, access may be frequent and involve carrying items to the top of the tank.

To gain access to the top of the tank, ladders or steps, hand holds and platforms were often found to be necessary, but not always provided. Where present they were often of poor design, in that they typically did not conform to the anthropometric criteria laid down in the check-list. (see Appendix 1).

To gain easy and safe access the steps of the ladder, including the first one, should be designed at the appropriate recommended heights; the hand holds should be placed for convenient grasping when climbing the steps and have the appropriate dimensions for comfortable grasp; the platforms should be large enough to provide a stable posture, particularly when carrying out activities such as pouring the concentrate into the tank.
The ladders were assessed in terms of:

- the dimensions of the rungs from an anthropometric point of view
- the presence of protrusions
- the presence of a storage facility and the ease of storing.

Of the tractor mounted sprayers assessed 10 out of 17 did not require ladders and of the 7 which did only 3 were considered adequate in terms of ease of use and their relative dimensions.

In 4 instances it was judged that ladders were required but were not provided. Of those that had ladders all were considered to be satisfactory to use.

Of the self-propelled sprayers in only one case (manufacturer 16) it was judged that a ladder facility was required but was not provided.

Handholds were assessed in terms of:

- functional position
- appropriateness to task
- dimensions.

Handholds were in many cases not provided. This was particularly true for tractor mounted sprayers. Of those which had handholds the majority were rated as poor or very poor in terms of their dimensions, shape and functional position. The absence of handholds in certain instances effectively forced the user to risk contamination. A particularly poor example of this was a model of manufacturer 11 where the absence of handholds forced the user to grasp the boom in its folded position to gain access to the cab.

Platforms were assessed in terms of:

- whether non-slip surfaces were present
- whether any spillage was retained
- suitability for use.

The assessment found that out of a total of 57 sprayers, 41 needed a platform to gain access to the tank. This can be broken down, by type of sprayer, as follows:
<table>
<thead>
<tr>
<th></th>
<th>Total (needed)</th>
<th>No rated 'poor'/ 'V.poor'</th>
</tr>
</thead>
<tbody>
<tr>
<td>mounted</td>
<td>13</td>
<td>9 (69%)</td>
</tr>
<tr>
<td>trailed</td>
<td>13</td>
<td>3 (23%)</td>
</tr>
<tr>
<td>self propelled/demount</td>
<td>15</td>
<td>5 (33%)</td>
</tr>
</tbody>
</table>

7.9 Instructions and warnings

These were assessed in terms of:

- ease of interpretation
- position in relation to hazard
- legibility.

Legibility

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>No. rated 'poor'/ 'V.poor'</th>
</tr>
</thead>
<tbody>
<tr>
<td>mounted</td>
<td>25</td>
<td>2 (15%)</td>
</tr>
<tr>
<td>trailed</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>self propelled/demount</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>not present</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

Ease of Interpretation

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>No. rated 'poor'/ 'V.poor'</th>
</tr>
</thead>
<tbody>
<tr>
<td>mounted</td>
<td>25</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>trailed</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>self propelled/demount</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>not present</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

Note: The high ‘not present’ figure relates to those sprayers which were assessed before having been fitted up with appropriate decals.
8.0 Attitude questionnaire

8.1 Development of questionnaire

A questionnaire was designed to assess the attitudes of sprayer manufacturers and importers to product safety and to gain a general picture of each company's product range and the size of their market.

The questionnaire was used as a structure for interviews with company representatives, with the aim of obtaining as reliable information as possible.

8.2 Piloting of the check list and attitude questionnaire

To check for consistence and integrity it was necessary to assess the attitude questionnaire by means of a pilot survey.

8.3 Site chosen for pilot survey

The attitude questionnaire was piloted at Schering Agriculture, Nottingham.

8.4 Results of pilot survey

The results gained from the pilot survey were recorded, analysed and reviewed, with minor detail revisions being made to phraseology and ordering of questions wherever appropriate. The complete questionnaire is shown in Appendix 2.

8.5 Survey of manufacturers attitudes to safety

An additional aim of the research project was to assess the attitudes of sprayer manufacturers including those who are major exporters to the UK.

The survey took the form of a structured interview using a questionnaire. It was proposed that the questionnaire should be of the interactive type, possibly supplemented by a postal survey to source information from those manufacturers whose location made visits non-economically viable. However, in the event no postal questionnaires were used, instead trained interviewers were used.
8.6 Results of analysis - survey of manufacturers' attitudes to safety

8.6.1 Training and instructional provision

Manufacturers and importers were asked to provide details relating to the amount of training provided for purchasers of their AFCS's. These figures should be treated as approximates, and in many instances maximums, as no account is taken here of the differences in the amount of training or the level of complexity between different models and types of AFCS.

No assessment of the quality of training was attempted as it was felt that this was beyond the scope of this study, although it was felt that this might on other occasions be a valuable exercise as the authors suspect considerable variation in the quality of the training experience between manufacturers.

Amount of training provided

   Not stated  2
   2 - 4 hours  4
   8 - 16 hours  9
   24 hours or above  3

All said that they provided training in the use of their sprayers, but it was obvious that 'training' meant different things to different people. Some of the larger companies apparently ran quite comprehensive training courses, while the small scale manufacturer typically provided instruction on delivery of the machine. There are possibly advantages and disadvantages to both of these methods. All said that their training included health and safety issues, but it was not possible to determine the extent to which these were dealt with in the training package.

8.6.2 Future provision of closed systems

Manufacturers and importers were asked about their intentions relating to the adoption of closed systems as a method of induction. All manufacturers stated that such systems would, if offered, be as optional extras rather than as standard provision.
Analysis of responses
Currently provided 2
Introduction planned for 1990/1991 5
Introduction planned for 1992/1993 2
No stated intention 10
No information collected 3

8.6.3 Legislative changes which are necessary

Manufacturers and importers were asked to state any changes which they thought were necessary to current regulations relating to pesticide application.

14 (67%) out of the total of 22 manufacturers sampled, stated that they felt there needed to be changes to current health and safety legislation, details of which are provided below:

- greater emphasis on engineering controls *(Manufacturer 1)*
- more clearly designed protocol/standards *(Manufacturer 2)*
- clearer guidelines and greater education of farmers (users) *(Manufacturer 3)*
- more detailed standards, not just guidelines *(Manufacturer 4)*
- mandatory inclusion of induction hoppers *(Manufacturer 6)*
- booms should be 'gullwing', not 'up/over' *(Manufacturer 7)*
- annual M.O.T. test for sprayers *(Manufacturer 8)*
- mandatory noise and 'roll over' protection *(Manufacturer 11)*
- wind speed recommendations should be revised, all booms should be hydraulic *(Manufacturer 12)*
• FEPA and C.O.S.H.H. were introduced too quickly and are not effectively policed (Manufacturer 15)

• legislation with respect to users not effectively policed (Manufacturer 16)

• legislation is poor on instructions relating to residues and wastes (Manufacturer 17)

• annual M.O.T. test for sprayers (Manufacturer 18)

• mandatory inclusion of induction hoppers, in-cab boom controls and clean water supplies (Manufacturer 21)

The remaining manufacturers had no comment to make.

8.6.4 Additional comments by different manufacturers

The following additional comments were volunteered by different manufacturers:

• would like to see the wooliness of current legislation removed (Manufacturer 1)

• would like to see C.O.S.H.H literature specifically aimed at sprayers (Manufacturer 3)

• all fitters should be trained at levels PA1/PA2 for when they are testing/repairing sprayers (Manufacturer 4)

• all machines should have an induction probe fitted, and all booms should be of the gullwing type (Manufacturer 6)

• not in favour of closed system concept as it adds too much complexity. Also there is a problem with closed systems of cross-contamination of residues (Manufacturer 12)

• the safety aspects have begun to 'hit home' to users, however the problem of residue is, as yet, unresolved (Manufacturer 15)
• Health and Safety at Work Act was a better form of legislation than C.O.S.H.H. Also, users who require high output sprayers demand easy to use and safe machines. *(Manufacturer 17)*

8.6.5 Sales figures for AFCS’s

The opportunity was taken during the survey to attempt to obtain information regarding sales of units. While it is accepted that the reliability of sales figures provided by manufacturers is questionable, it was felt that this would give some indication of the market share. It should be noted however, that the larger manufacturers were particularly reluctant to pass on this information.

Sales figures provided represent totals rather than being categorised by type of sprayer as it was felt that this degree of detail was unnecessary given the fact that the reliability of the figures was open to question.

**Annual sales figures (12 months preceding interview)**

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<th>Category</th>
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<td>less than 15</td>
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<td>16 to 50</td>
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<td>more than 100</td>
<td>5</td>
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<td>not stated</td>
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</table>
8.7 Countries in which sprayers were marketed

Further information was sought regarding the countries to whom manufacturers sold their products.

1  U.K.; Saudi Arabia
6  U.K.; N.Z.; U.S.A.; Canada; Eire; Thailand
7  EEC; U.S.A.; U.S.S.R.; Poland; Africa; Middle East
8  U.K.; France; Eire; Middle East; India; Africa
9  U.K.; Eire
10 U.K.; Eire
11 U.K.; Eire
12 U.K.; U.S.A.; Australia; France; Germany; S. Africa; Algeria; Czechoslovakia
15 U.K.; Holland
17 U.K.; Eire
18 U.K.; Canada; Saudi Arabia; U.K.; France
19 U.K.; France
20 U.K.; France; Belgium; Italy; Spain; Hungary
21 U.K.; Eire; France; Germany; Sweden
22 S. Africa; Saudi Arabia; Brazil

The remainder of the manufacturers were UK only.

9.0 Discussion

This discussion section, for reasons that have become apparent in this report, is mainly about design and it will be argued that whilst some design changes could be made to improve the safety of operators who use sprayers, there are fundamental problems to making the spraying operation completely safe. However, sprayer safety is not only a design issue, there are other issues which are of a marketing and economic nature which also have implications for the safety of operators of spraying machines. These will also be referred to in this section.

Finally, the attitude and policies of the manufacturers and importers themselves will be discussed.

9.1 Introduction

In designing a safe pesticide application system there is obviously a major conflict. Many of the design problems identified earlier could, on their own, be solved relatively easily. However to
design an integrated system which is entirely safe, which avoids the possibility of operator contamination, requires that the operator should not have to risk any form of direct contact with pesticide whatsoever. This suggests designing the system in such a way that the operator never leaves a protected environment, e.g., the cab, and that all operations including induction, spraying, routine adjustment and rinsing the system are carried out remotely. Whilst there may be possibilities to solve the design problems associated with the carrying out of some of these activities in a remote manner, a design system that will enable all these activities to be carried out remotely is not feasible at present and is likely to be prohibitively expensive. The other alternative is to put a barrier between the operator and the hazard by use of effective PPE. Even if protective clothing is well designed and easy to use and if the system is designed to support the use of PPE, there are considerable problems to overcome. Once protective clothing has been exposed to pesticide, either through spillage, splashing or through simply walking through sprayed crops, it needs to be taken off in a ‘clean’ area and stored in an appropriate place. Such an operation is similar to “tenting” as used when discarding PPE in asbestos operations but this would not seem to be feasible in the spraying situation. The consequence is that the PPE is either shed whilst still outside the cab, thereby creating the possibility of ordinary clothing becoming contaminated which is then worn in the cab, or all PPE (or parts of it) are on kept risking contamination of the cab. Where a tractor is used, it may also be employed for other purposes as well as spraying, in which case a ‘contaminated cab’ poses risks for others.

This discourse suggests that fundamentally the system of spraying presently in use is unsound, unsafe and needs to be totally rethought if the fundamental problem of protection of the operator is to be solved.

The foregoing aside, it was apparent that, in general, there have been some significant improvements in the design of AFCS’s, in terms of user safety, when compared with the findings of Left (1986). However, there still exist fundamental design flaws common to almost all manufacturers, (see below), and improvements are far from universal either in terms of manufacturers or in terms of models produced by individual manufacturers. It is apparent that the majority of manufacturers are generally placing greater emphasis upon designing for safety, particularly in view of recent changes in legislation - specifically C.O.S.H.H. and F.E.P.A.

The specific design features which were investigated will now be discussed in detail.
9.2 Induction

This study has confirmed the view of Left (1986) that pouring pesticide liquid directly into the top of the tank is hazardous both from the point of view of slipping and falling and contamination.

Although manufacturers are increasingly employing induction hoppers in place of manual methods of pouring pesticide liquid, their design from a safety point of view is far from satisfactory.

One of the most fundamental design flaws in the use of induction hoppers is that it requires the operator to handle a pesticide container and physically pour this into the hopper with all the associated risks of splashing and spilling and handling wet items and components. The risk is increased because of the poor design of the sprayer hopper and pesticide container which work against the wearing of suitable PPE particularly gloves, respirators and visors or goggles.

A further problem with the design relates to the access for pouring in to the hopper. In many instances the size, shape and capacity did not allow easy pouring. On some sprayers the opening of the bowl lid was obstructed because of the proximity of other sprayer components. In addition, removal of the lids, especially the screw top and lift off type, required two hands and even so was often difficult to open and close. As a result of this the pesticide container must be placed somewhere whilst this operation takes place with all the risks that that entails.

Another problem was related to those bowls which had to be released from a storage position and swung into place for induction to take place. Operating the mechanism, which was usually of the cantilever type, particularly when returning the bowl to its storage position, often required great strength and created a risk of snagging or entrapment. It would appear that the development of a well balanced cantilever type mechanism, requiring minimal physical effort, is something which could be achieved with a relatively low research and development budget.

A common problem was the siting of the induction bowl beneath folded booms, where dripping nozzles could potentially pose a serious risk of contamination, especially if the sprayer tank is being refilled immediately after spraying.

It would not seem beyond the scope of designers, even if booms must be positioned so, to protect operators from this hazard.
The use of a probe with some equipment again posed hazards of a different kind. In many cases the control valve did not allow the operator to know whether or not flow was taking place and in no cases were there effective clean facilities provided to rinse the probe.

Methods of induction which rely on manual handling of pesticide containers is fundamentally unsafe. It is interesting to note that a significant number of manufacturers are currently investigating the feasibility of introducing ‘direct injection’ or ‘closed system’ methods of induction. These devices are dealt with separately in Appendix 4 'Appraisal of closed transfer and injection systems'.

Although manufacturers are increasingly employing hoppers to replace manual methods of induction, their design from a safety point of view, is far from satisfactory.

9.3 Provision of container washing facilities

The provision of container washing facilities was more likely to be a standard feature on the larger machines than on the smaller ones. Where the facility was present there appeared to be little difficulty in its ease of use, and it is recommended that this should be a standard provision with all sprayers.

9.4 Boom operation

The major problem with boom geometry was the method in which the booms were stored. They were generally positioned such that nozzles were directly above the area in which the operator carried out many sprayer activities. The need to address this problem was referred to earlier in the discussion. A further problem was that entry and exit to the cab was often obstructed by the position of the stored booms. This would appear to be a fundamental design fault.

Four of the sprayers had booms which reached heights likely to touch overhead power lines when unfolding. It is recognised however that power line height varies according to the area of the country and safe opening height needs to be assessed in the light of local conditions.

The physical effort required to manually open and close booms was in many instances considerable and involved the risk of pinching and trapping. Manual operation of booms needs to be designed carefully to ensure that it does not require undue strain or pose other hazards to the operator.
9.5 The cab environment

Comments on the quality of the controls and displays within the cab have been given elsewhere. In most instances the design of the cab was considered to be adequate, although it was not possible to test whether the air filtration and air conditioning system met the latest Health and Safety Executive requirements, obviously this is the standard that should be met with all cabs.

In the past it has been known for hoses to be routed through the cab, which is totally unacceptable from both a contamination risk and as an effective seal to the outside atmosphere point of view.

9.6 Access for the purpose of maintenance

The provision of access facilities such as ladders, handholds and platforms to carry out maintenance activities was often found to be very inadequate. Very little use had been made of known ergonomics data in relation to step height, handle shape and size and platform dimensions. As a consequence of this, gaining access to the sprayer was often very hazardous. Such problems could be relatively easily overcome with proper design.

9.7 Controls and displays

The types of flow valve controls present for those AFCS's evaluated were almost universally of the 'Safi valve' type.

While it is accepted that the majority of experienced sprayer operators are likely to be familiar with the operation of this type of valve control, it is felt that there are significant deficiencies in their design in terms of ease and convenience of use.

Specifically, it was considered that such controls are lacking in clear and effective 'flow direction' markings. Furthermore, they typically lack any form of positive stop which would act to provide feedback for the user regarding the status of the valve.

Labelling relating to the status of valves was, in many instances, found to be of poor quality, both in terms of information content, construction materials and relative position.
There were numerous instances in which the directional movement of controls was found to be in planes which did not conform to recognise conventions. eg lever 'Down' for upward movement of the booms. Such controls are likely to lead to errors.

There was considerable variation between manufacturers in terms of the quality of information presented to the user relating to boom status.

Problems with the panel layout included poor presentation of graphic information, poor labelling and more fundamentally poor positioning of displays in terms of display/control orientation to the user.

The above design deficiencies in control movement, labelling and position among others all have implications for safety in terms of inadvertent and / or inappropriate use.

9.8 Drainage of the tank

A further area of concern relates to methods of sprayer tank drainage. As stated previously only 3 models of those AFCS evaluated had some form of remote drain tap fitted.

The most common form of drainage necessitated the user to crawl underneath the sprayer and either remove a plug or connect a pipe to the valve at the base of the tank. In either instance, particularly the former, it is difficult to see how the user could avoid contact with the pesticide as it drained from the tank.

Given the above situation it is apparent that users are faced with three options:

a) cope with the difficulties of removing the drain plug

b) 'spray off' any residue until the tank is empty

c) leave the residue in the sprayer tank.

In the case of (a) there is the risk of contamination of the user; for (b) there is the implication of inappropriate use or over-dosing of the crop; and for (c) degradation of seals and associated components within the sprayer and possible contamination of the next substance used. Again, in
the opinion of the Authors, it is not beyond the scope of any reasonably competent designer to solve this problem and ensure the complete safety of the user when draining the tank.

9.9 Tank contents gauges

A variety of types of sprayer tank contents gauges were encountered during the course of the evaluation, ranging from simple moulded text on the tank, commonly found on small mounted sprayers, to high quality text engraved on laminate. These designs were rather simple and relied upon the translucent properties of the sprayer tank material to read the contents.

By far the most common form of contents gauge was a clear plastic tube backed by an adhesive decal. The quality of these decals, as with all other decals evaluated, varied considerably between manufacturers, many were of poor quality and were showing signs of losing their adhesive qualities when evaluated - prior to their use.

By far the most durable form of presentation was a clear tube backed by text engraved upon a plastic laminate typically white on either red or black. Although no incidence of damage was observed, the gauges examined did not appear to be designed to withstand any hard abuse as would occur if they were inadvertently struck by an object. If this occurred then leakage of the pesticide solution may well result. Ideally the gauges should be located to minimise the possibility of damage.

9.10 Sprayer tanks

Sprayer tanks were constructed either from plastic (blow mould or injection moulded forms), fibre glass or stainless steel. It is the opinion of the authors that fibreglass, commonly used by smaller manufacturers, as a material is unsuitable for the construction of sprayer tanks. It was apparent from this research and previous research undertaken by the author, (Feeney 1989) that leakage was commonplace due to the splitting and cracking of the fibre glass, apparently due to vibration particularly at pump inlet points.

9.11 Optional or non-optional safety features

The first issue is the way the basic sprayer package is marketed. Sales literature illustrates the basic sprayer model with the minimum of additional facilities. Invariably these additional facilities are safety related and are offered as optional extras. This is particularly true for the medium and smaller sprayer models. Almost all manufacturers offer induction hoppers, P.P.E stores and clean
water supplies as optional features for their sprayers. Many manufacturers drew attention to the fact that desirable safety related features, such as the above, are offered as 'optional extras', rather than fitted as standard due to reluctance on the part of many potential purchasers to pay for what they perceive to be an additional and often 'unnecessary' cost.

This problem was of particular importance to small - low cost - mounted sprayers, as the addition of such features adds considerably to the cost of the sprayer, particularly when expressed as a percentage of total cost.

While it is now generally accepted that the provision of such design features is highly desirable, a dilemma exists for legislators in that, on the one hand, it would appear logical to make fitment of such design features a legal requirement for all ARCS’s, on the other this could well have other adverse and undesirable consequences, for the following reasons:

a) It was apparent that manufacturers of larger machines would welcome formalised design criteria, and mandatory fitment of features such as induction hoppers, water supplies and P.P.E. stores etc. However their view was influenced by the fact that this would almost certainly result in smaller manufacturers not being able to compete because the R & D investment necessary to meet the requirements of mandatory standards would be prohibitive.

While such an outcome may not be wholly undesirable, since this would effectively remove many poor quality products from the UK market, it does have the added implication that the sprayer production would be in the hands of a much smaller number of producers. Evidence from other industries suggests that this is an undesirable consequence as it is likely to result in the formation of cartels, which are generally regarded to be more difficult to deal with in legislative terms.

b) A secondary, but related, issue is that the addition of such features to those sprayers at the bottom end of the market, specifically small mounted units, would effectively place the price of these devices beyond the means of small scale users, with the result that they would be forced to employ contractors to undertake applications.

A further issue is that when certain features are optional extras and not an integral part of the design, they are often poorly positioned and create difficulties and possible hazards for the operator.
9.12 Use of subcontracts

Related to the issue described above is the subject of subcontractors. It is the opinion of the authors that the recent and increasing growth in the number of ‘Spraying Contractors’ produces an additional, and in many ways undesirable, contingency given that when work is undertaken on a contractual basis there are increased pressures in terms of time and cost, with work effectively being undertaken on what amounts to a piece-rate basis. There is good evidence, from other industries, that payment structures such as these tend to have the undesirable effect of inducing workers to ‘cut corners’, with the resultant deficit, in operator safety and environment pollution.

These issues aside, the remainder of this section will discuss design issues in relation to the safety of the system features as they are found at present.

9.13 Attitudes of manufacturers towards safety

From the results of the questionnaire survey it was apparent that the majority of manufacturers were aware of the need for safety innovations particularly the need for improvements in the method(s) of induction as this is arguably the most significant design deficiency in the design of AFCS’s when viewed by terms of the C.O.S.H.H. regulations. In general, manufacturers were aware of the need for the development of engineering controls, though most justified non-fitment for reasons of cost and the absence of mandatory legislation. Several manufacturers did make the point that there appears to have been an increased awareness amongst purchasers of the potential hazards of dealing with agro-chemicals and were apparently, as a result, requesting the fitment of desirable features such as low-level induction bowls and clean water supplies and container washers. Hence, several manufacturers made the point that while such features were officially offered as optional fitment the situation was now that they were increasingly being fitted to the majority of sprayers sold.

Less than half of the manufacturers stated that they had or intended to provide closed systems within the foreseeable future. This may be partly a reflection on their attitude to the need for such systems and partly due to the cost, particularly for smaller machines.

The attitude of manufacturers varied considerably towards training. Whilst it was not possible to assess the quality of the training it would appear that the manufacturers of larger machines gave more time than those of smaller machines.
A main result of the attitude survey was that the majority of manufacturers would be happy with more detailed standards and more effective legislation to cover design and operation of sprayers.

10.0 Conclusions

10.1 Introduction

The survey of crop sprayers was comprehensive and adequately represented the range of equipment currently available in the UK. A wide range of sprayers was evaluated from which it was possible to obtain a clear picture of the 'state of the art' with respect to crop sprayer design. Manufacturers were in general co-operative and expressed their views on safety and design clearly and constructively.

The analysis of the results of the survey of AFC's suggest that there are fundamental design faults which need to be addressed (see Appendix 5). It suggests that there exists considerable scope for the enhancement and improvement of design, to improve the safety of the majority of sprayers and related equipment currently marketed in the U.K. It is felt that whilst many of the design improvements required are relatively simple and would not necessarily add to the cost of the sprayer save for amortising development costs, more far reaching changes in the design concepts are required to reduce the risk to an acceptable level.

On the newer and larger sprayers a greater number of safety or safety related features were present although not always integrated into the overall design. Many of the medium to small models however had serious design shortcomings.

10.2 Trends

Due to the shortcomings in design it seems likely that the future will see the fitment of an induction hopper as standard, even for small mounted sprayers with a move to some form of pesticide induction system which minimises the possibility for contamination for all sprayers in the not too distant future.

Probably the most significant innovation since Left's (1986) report has been the development of direct injection / closed systems of induction with the result that most of the major manufacturers appear to be moving towards their fitment, or optional fitment, particularly for large AFCS's.
It would appear that the majority of manufacturers are looking towards buying in this technology from those organisations which are currently developing it (see Appendix 4). However, the future may see the development of new forms of safe induction systems by other companies, for example by the suppliers of pesticides.

The addition of desirable safety features, such as safe induction systems, clean water facilities and P.P.E. stores, etc, will add to the cost of sprayers. Consequently, it may well be that small mounted AFCS's may disappear from the market place, and a resultant increase in the employment of 'Spraying Contractors' by farmers who only have infrequent need for spraying.

10.3 Design

1) There is a need for further research and development in the design of induction systems specifically relating to:

   • ease of operation
   
   • the elimination of the risk of contamination
   
   • an effective and efficient washing / mixing system for induction hoppers.

2) Certain other tasks which the operator is required to do pose an unacceptable level of hazard and alternative design solutions to obviate the risk should be found.

3) With regard to all the manufacturers models evaluated there is a general failure to implement basic ergonomics principles in relation to operator safety, convenience and ease of use.

4) Warnings, labelling and instructions are generally poor and little attention has been paid to their design.

5) Fundamental changes in design are required which will make the operation of spraying and its associated activities safer and free from the possibility of contamination.

Recommendations for design based on the findings of this study are shown in Section 11.0.
Attitudes

It is clear that the attitude of many manufacturers towards safety is that they recognise improvements are needed and these should be as a result of improved standards backed up by effective legislation. However, there are economic and technological limits to what can be achieved in the foreseeable future.
11.0 Design recommendations

From the results of the study described, the following recommendations are made:

Recommendation 1 - Clean water supply

A clean water supply should be present, mounted on the sprayer, with a minimum capacity of 15 litres. The outlet should have the capacity for directional operation with a hose (or its alternative) at least 3m long to allow for douching of the operator in the event of contamination and rinsing components as necessary.

Recommendation 2 - Induction methods

Although still in early stages of development, closed induction systems and direct injection systems provide the greatest safety for operators during induction and from the point of view of environmental safety. In future, all induction systems must be of the closed or direct injection type.

A closed system must avoid the requirement for chemical concentrate to be manually decanted into or out of the sprayer.

To avoid waste, closed systems must provide for chemicals to be mixed just prior to spraying.

All closed systems must have an automatic flushing facility.

All closed systems must be capable of accepting soluble powders and granular chemicals.

Comment

Induction by means of either a probe or manual pouring is not to be recommended for safety reasons.

Recommendation 3 - Sprayer controls

It is considered highly desirable that all sprayers should have in-cab (remote) controls for all boom operations.
All controls should be clearly labelled.

Controls should operate in planes which conform to recognised conventions.

Controls should be designed to failsafe, and in such a way as to prevent inadvertent use (see relevant ISO Standard).

Separate and clearly identifiable in-cab sprayer controls should be present which perform the following functions:

- an emergency output ‘kill switch’
- an overall system ‘on’ / ‘off’ switch
- individual boom segment controls
- boom raising / lowering controls

Users should be provided with clear and accurate information for calibration, specifically - distance covered and application rate.

Comment

Manual boom folding and raising and lowering controls, as well as application rate controls which must be operated through the rear window aperture of the host vehicle are considered to be highly undesirable.

Under no circumstances should hoses containing chemicals be routed through the cab.

Recommendation 4 - Personal protective equipment stores

Ideally, two separately designated P.P.E. stores should be present, one for the storage of clean items of PPE and one for the storage of soiled PPE items.

Each store should be:
- positioned close to the cab of the host vehicle, for convenience
- easily accessible
- sealed to prevent contamination from spray drift
- easy to clean and maintain
- positioned away from other hazards such as drips from nozzles.

Comment

It is recognised that even if PPE is well designed there is no completely safe method of using it when spraying, primarily due to the fact that the system has no 'clean area'. Storage has to be viewed in this context and a proper store, suitable for easy and effective use can improve a difficult situation. As far as possible it should meet ergonomics criteria and be designed bearing in mind the specific difficulties and hazards facing sprayer operators.

Recommendation 5 - Boom storage and use

Boom storage should either be by electrical or hydraulic power assistance and not by manual raising, lowering or folding.

To minimise the risk of contamination, control of the booms should be ideally from within the cab of the host vehicle.

Booms should be stored in a position which does not produce hazards either in the form of obstruction to getting in and out of the cab or moving around the sprayer.

The operator should be protected from contamination from dripping nozzles either by means of location of the booms when stored or by the provision of protective shelters or gutters.

Ideally, the booms should fold in such a way that the nozzles face upwards rather than downwards, to reduce the possibility of contamination of the user or the environment through dripping from a faulty nozzle.
When unfolded, the boom nozzle system should be designed to avoid the possibility of dripping when spraying has ceased.

Manufacturers, when considering the maximum height that any part of the boom might reach during opening and folding, should take advice from the appropriate electrical supply company.

**Recommendation 6 - The pump**

The pump should be positioned to allow easy access for maintenance purposes.

It should be ‘positively located’ on the sprayer.

All user maintainable parts should be easily accessible from outside the tank.

Under no circumstances should there be any requirement for the operator to enter into the tank.

**Recommendation 7 - Hose clips**

Hose clips should be maintainable, or easily replaceable in the event of failure, with minimal tools.

Non user maintainable type clips are not recommended.

**Recommendation 8 - The cab**

The cab should be sealed with an effective atmospheric filtration device using carbon filters (according to PM 74 requirements) to provide the user with a safe, clean, working environment.

The cab should be glazed to the extent that it provides the user with a high level of all round visibility, particularly to the rear, and the area which has been covered by the application.

**Recommendation 9 - Tank drainage**

A safe method of draining off unused pesticide solution must be provided.

The operation of this device should be remote from any source of possible contamination.
The position of the drainage device is considered to be potentially highly hazardous if positioned at the sump of the sprayer tank, necessitating the user to crawl underneath the sprayer for its operation.

All taps, plugs etc must be accessible and easily operated without any risk of contamination to the operator.

**Recommendation 10 - Presentation of information**

Information presented should be clear, concise and appropriate to the needs of the user.

It should be presented at the point of hazard / operational control to which it pertains.

Information should be presented either on highly durable '10 year vinyl', or by engraved text on a laminate.

A minimum size type face of 18 point should be used.

All signs must conform with ISO recommendations on health signs at work (COM 9664).

**Comment**

Moulded text is considered to be undesirable due to the difficulties involved in reading.

**Recommendation 11 - Contents gauge**

The contents gauge should provide the user with an accurate indication to within 5% of the total contents of the tank.

It should be positioned such that it can be read when the user is both inside and outside the cab of the host vehicle.

It should possess calibrations in both metric and imperial equivalent scales.
Information should be presented either on highly durable '10 year vinyl', by engraving text on a laminate.

A minimum size type face of 18 point should be used (see earlier reference to ISO recommendations).

**Comment**

Moulded text is considered to be undesirable in terms of the difficulties involved in reading.

**Recommendation 12 - Platforms**

Platforms should not retain any spillages.

They should have a non-slip surface.

Platforms should be guarded with a toe-board and a rail of not less than 1m above the base of the platform.

Platforms should comply with the appropriate CEN and ISO Standards as appropriate.

**Recommendation 13 - Ladders**

Ladders should have a non-slip surface.

They should have round or oval rungs, rather than square.

They should have a minimum rung width of 30cm and a maximum tread depth of 40cm; (maximum height of the first step above the ground should be no greater than 43cm).

If ladders fold this should be possible with one hand only.

All ladders should comply with the relevant ISO and CEN Standards as appropriate.
Recommendation 14 - Handholds

Handholds should be well located, in functional positions appropriate to the task.

Handholds should not favour predominantly either left or right handed use.

They should be of the appropriate recommended anthropometric dimensions.

Comment

With regard to Recommendation 12, 13, and 14, nothing stated should be contrary to the UK Machinery Directive and appropriate UK regulations.
An ergonomic evaluation of agricultural crop sprayers

Volume 2 - Appendices

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<td>8.2 Ladders.</td>
<td>50</td>
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<td></td>
<td>8.3 Platforms.</td>
<td>52</td>
</tr>
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<td>9</td>
<td>HAZARD WARNINGS AND INSTRUCTIONS.</td>
<td>55</td>
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<tr>
<td></td>
<td>TESTING OF THE SPRAYERS.</td>
<td>57</td>
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<td></td>
<td>UNIQUE DESIGNS OR NEW INNOVATIONS.</td>
<td>57</td>
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<tr>
<td></td>
<td>OVERALL CONCLUSIONS ABOUT THE MODEL/MODEL RANGE.</td>
<td>57</td>
</tr>
</tbody>
</table>
1 PESTICIDE FILLING FACILITIES.

Pesticide induction is potentially the most hazardous task undertaken in any spraying operation. It is at this point that concentrated, and in some instances highly toxic, pesticides are being handled, exposing the user to the risks of contamination through absorption, inhalation or ingestion. This risk may be increased if the personal protective clothing (PPE) is unsuitable for the task or if it is old, damaged or ill-fitting. Even if the PPE is worn and effective, if the spray unit itself is poorly designed or maintained, accidents may still occur. Therefore it is of the utmost importance that all spraying equipment is designed taking full cognisance of all relevant ergonomic criteria.

There are at present, four main methods of inducting the pesticides into the sprayer;

a. By means of a low-level induction bowl. If the bowl is placed at a suitable height for ease of pouring, thereby eliminating the need to climb up on the equipment whilst carrying concentrated pesticides. The major disadvantages with the system are that:

   i. concentrated pesticides are being handled since the operator is required to decant the required amount into a measuring container in instances where a scale is not provided of the side of the pesticide container;

   ii. the bowl may often be located inappropriately on the sprayer, that is, it is not desirable to have the bowl underneath the booms.

   iii. it may be placed too close to other equipment which may be contaminated if spilling or splashing occurs.

b. By means of a probe. This method requires that the pesticide is drawn up the probe thereby eliminating the need to handle the pesticide, (except again in some cases where the pesticides need to be measured into another container first). The major disadvantage with the probe is cleaning it after use prior to storing. This requires a conveniently available water supply.

c. Manual induction of the pesticides. This method of induction presents the greatest risk to the user for the following reasons:

   i. pouring of the pesticide concentrate into a mixing/calibration vessel;

   ii. mounting the sprayer to gain access to the filling aperture;

   iii. pouring the pesticide concentrate into the tank at or above shoulder height.

d. Closed induction systems; - In the future it is envisaged that closed induction systems will become commonplace thereby eliminating many of the problems associated with handling and cleaning of equipment. At present such systems are still being developed.
All systems should be designed in such a way as to allow their use by individuals of the range 5th percentile female to 95th percentile male by stature (a correction factor of 5% shall be allowed for PPE).

1.1 WATER SUPPLY.

A clean water supply should be present, mounted on the sprayer. Sufficient water (recommended 15 - 20 litres) is required for decontamination of;

i. the operator;
ii. PPE;
iii. measuring containers;
iv. contaminated parts of the sprayer.
v. equipment, eg nozzles.

The pressure and direction of the water flow should be controllable. For example, a rinsing gun and hose attachment to the water supply allows more freedom of use.

1.1.1 Is a clean water supply available?

   as standard - YES [ ]
   as optional - YES [ ]

   If no, please proceed to next section - NO [ ]

1.1.2 If yes, what is/are its capacity, in litres? .................................................................

   ........................................................................................................................................

   15 - 20 Litres

   ........................................................................................................................................

1.1.3 Please describe the position of the water supply, and note any hazards present.

   ........................................................................................................................................

   ........................................................................................................................................

   ........................................................................................................................................

   ........................................................................................................................................

   ........................................................................................................................................

   ........................................................................................................................................
1.1.4 How easy is the water to use in the cleansing of:

<table>
<thead>
<tr>
<th>V. EASY</th>
<th>EASY</th>
<th>ADEQUATE</th>
<th>DIFFICULT</th>
<th>V. DIFFICULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>The operator;</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>PPE;</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Measuring containers;</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Equipment eg. nozzles;</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.

GENERAL COMMENTS.

1.1.5 Is there a means of regulating the direction of water from the tank?

YES [ ]

NO [ ]

1.1.6 Is there a means of controlling the pressure of the water?

YES [ ]

NO [ ]

1.1.7 How easy is the tap to operate?

VERY EASY [ ]

EASY [ ]

ADEQUATE [ ]

DIFFICULT [ ]

VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.

GENERAL COMMENTS.

1.1.8 How easy is the water tank to fill?

VERY EASY [ ]

EASY [ ]

ADEQUATE [ ]

DIFFICULT [ ]

VERY DIFFICULT [ ]
OVERALL COMMENTS ABOUT THE WATER SUPPLY.

Prompts - capacity
- ease of cleansing
- regulation of direction
- pressure
- operation of tap
- filling water tank.

1.2 LOW LEVEL INDUCTION BOWL.

The following aspects must be considered in relation to the induction bowl:

i. it is not desirable to have the bowl directly beneath the booms;
ii. it must be easy for a gloved hand to release any retaining mechanism for
   the bowl, allowing it to be swung into position for use;
iii. it should be easy to open the bowl with one hand;
iv. it is desirable for the top of the bowl to be within 73 - 92 cm (29 - 36"),
    measured from the ground;
v. it must be easy to unscrew, hinge back or remove the lid of the bowl,
    without any risk of discomfort or injury;
vi. a rapid rate of induction must be possible from different types of
    containers. An aperture of no less than 24 cm (9.5") in diameter should
    be present or 34 cm (13.5") in diameter if a container washer is present
    within the induction bowl.
vii. it must allow for the use of soluble packages;
viii. a flushing facility must be available to thoroughly mix the pesticide
     solution and to ensure that no residues remain.

1.2.1 How well is the induction bowl located in relation to the booms?

           VERY WELL [ ]
           WELL [ ]
           ADEQUATE [ ]
           POOR [ ]
           VERY POOR [ ]
IF RATED POOR OR VERY POOR, PLEASE GIVE DETAILS.

GENERAL COMMENTS.

1.2.2 Is the operator required to swing the bowl out or down to gain access?
   YES [ ]
   If no, please proceed to question 1.2.4 - NO [ ]

1.2.3 If yes; (a) Is the mechanism for retaining the bowl easily accessible?
   YES [ ]
   NO [ ]

IF NO, PLEASE GIVE DETAILS.

(b) Is the operator risking injury in performing this task?
   YES [ ]
   NO [ ]

IF YES, PLEASE GIVE DETAILS.

1.2.4 What is the distance to the top of the bowl when measured from the ground?

---

73 - 92 cm
(29 - 36")
1.2.5 Please give a general description of the lid to the induction bowl.
   Prompts - positive stop
   - hinged/screw lid
   - ease of gripping

1.2.6 Rate the ease with which the lid of the bowl can be removed.
   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

   IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS

   GENERAL COMMENTS

1.2.7 Measure the width of the aperture

   > 34 cm (13.5"

1.2.8 What is the capacity of the induction bowl?

1.2.9 Will the induction bowl allow for the use of soluble pesticide packages?
   YES [ ]
   NO [ ]

1.2.10 Is a flushing facility for the bowl present?
   YES [ ]
   NO [ ]
Two control valves are present on the induction bowl, one which controls the flow of water to the induction bowl and the other which controls the pesticide solution leaving the induction bowl. It is desirable that the controls:

i. are located so that no part of the user is at risk of contamination whilst operating them;
ii. are easily, (eg in poor light), and permanently identifiable as to the functions of the valve (ie which position is on, and which position is off);
iii. conform to recognised conventions;
iv. are easily operable, thus avoiding undue exertion by the operator.

1.2.11 When using the control valves, is the user exposed to any potential hazards from other pieces of equipment?

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water control valve;</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Pesticide solution control valve;</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

IF YES, PLEASE GIVE DETAILS.

1.2.12 Are the on/off positions of the control valves easily identifiable?

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water control valve;</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Pesticide solution control valve;</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

IF NO, PLEASE GIVE DETAILS.

1.2.13 Are instructions marked on the handles for the functional use of the control valves?

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water control valve;</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Pesticide solution control valve;</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

1.2.14 If yes, how are they presented?

<table>
<thead>
<tr>
<th></th>
<th>DECAL</th>
<th>MOULDED</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water control valve;</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Pesticide solution control valve;</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

IF OTHER, PLEASE GIVE DETAILS.
1.2.15 Is the information well presented?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Water control valve;</td>
<td>[ ]</td>
</tr>
<tr>
<td>Pesticide solution control valve;</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

IF NO, PLEASE GIVE DETAILS...

1.2.16 Does the operation of the control valves conform to recognised conventions?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Water control valve;</td>
<td>[ ]</td>
</tr>
<tr>
<td>Pesticide solution control valve;</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

IF NO, PLEASE GIVE DETAILS...

1.2.17 Rate the ease of use of the control valve with one hand.

V. EASY EASY ADEQUATE DIFFICULT V. DIFFICULT

| Water control; | [ ] | [ ] | [ ] | [ ] | [ ] |
| Pesticide control; | [ ] | [ ] | [ ] | [ ] | [ ] |

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS...

GENERAL COMMENTS...

Some of the low level induction bowls have pesticide container washing facilities in conjunction with them. Often it is simply a hose attached to the side of the induction bowl. Otherwise an automatic pesticide container washing facility is present. To operate these the user is required to:

i. upturn the container onto a nozzle;
ii. press down on the container to activate water jets which flush out the residue into the induction bowl;
iii. remove the container.

It is desirable for the top of this form of container washer to be positioned within the range of 73 - 92 cm (29 - 36"), measured from the ground.
1.2.18 Is a pesticide container washing facility available?  

YES [ ]  

If no, please proceed to question 1.2.22 - NO [ ]

1.2.19 What form of container washing facility is present?  

AUTOMATIC [ ]  
HOSE [ ]  
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS.

1.2.20 Where is the container washer positioned?  

1.2.21 If the pesticide container washer is positioned inside the induction bowl, is it likely to cause splashing when inducing chemicals?  

YES [ ]  
NO [ ]

IF YES, PLEASE GIVE DETAILS.

Instructions should be present for the safe use of the induction bowl. It is desirable for these to be in the form of either a warning or in the form of an instruction. They must be;

i. positioned in close proximity to the subject of the instruction;  
ii. appropriate;  
iii. of a long wearing material.

1.2.22 Are instructions present?  

YES [ ]  

If no, please proceed to question 1.3 - NO [ ]

1.2.23 If yes, what forms are they in?  

WARNING [ ]  
INSTRUCTION [ ]  
OTHER [ ]

IF OTHER, PLEASE SPECIFY.
1.2.24 How are the instructions presented?

DECAL [ ]
MOULDED [ ]
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS...............................

.................................................................

.................................................................

1.2.25 How well are they placed in relation to the task?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS...........

.................................................................

.................................................................

GENERAL COMMENTS...........................................

.................................................................

.................................................................

1.2.26 How well do the instructions impart the relevant information?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS...........

.................................................................

.................................................................

GENERAL COMMENTS...........................................

.................................................................

.................................................................
OVERALL GENERAL COMMENTS FOR THE LOW LEVEL INDUCTION BOWL.

Prompts:  
- location of the bowl  
- access to the bowl  
- height of the bowl  
- opening of the bowl  
- rapid induction  
- soluble packages  
- bowl flushing facilities  
- the control valve  
- container washing facilities  
- instructions/warnings

1.3 PROBE METHOD.

The desirable features to be considered in connection with the probe are:

i. the provision of an anti-drip valve;
ii. the switch which operates the control valve having a fail-safe facility in the form of a "dead man's handle";
iii. the provision of cleaning facilities, to allow cleaning of the probe prior to storage;
iv. a parking facility, to store the probe away from other equipment;
v. appropriate instructions.

1.3.1 Does the probe have an anti-drip valve?

YES [ ]
NO [ ]

1.3.2 Is a "dead man's handle" present on the probe?

YES [ ]
NO [ ]

1.3.3 If no, please describe the controls for the probe...

The control valve for the probe must:

i. be located so that no part of the user is at risk of contamination whilst operating it;
ii. be easily (eg in poor light), and permanently identifiable as to the
functions of the control (ie which position is on and which position is off);
iii. conform to recognised conventions;
iv. be easily operable, thus avoiding undue exertion by the operator.

1.3.4 When using the control valve, is the user exposed to any potential hazards from other pieces of equipment?

YES [ ]
NO [ ]

IF YES, PLEASE GIVE DETAILS...

1.3.5 Are the on/off positions of the control valve easily identifiable?

YES [ ]
NO [ ]

1.3.6 Are instructions marked on the handles for the functional use of the control valve?

YES [ ]
NO [ ]

1.3.7 If yes, how are they presented?

DECAL [ ]
MOULDED [ ]
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS...

1.3.8 Is the information well presented?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS...

1.3.9 Does the operation of the control valve conform to recognised conventions?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS...
1.3.10 Rate the ease of use of the control valve with one hand.

   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS

GENERAL COMMENTS

1.3.11 Are effective cleaning facilities for the probe present?

   YES [ ]
   NO [ ]

1.3.12 If yes, how easy are they to use?

   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS

GENERAL COMMENTS

1.3.13 Is a pesticide metering device present on the probe?

   YES [ ]
   NO [ ]

1.3.14 Are effective storage facilities available for the probe?

   YES [ ]
   NO [ ]

Instructions should be present for the safe use of the probe. It is desirable for these to be in the form of either a warning or in the form of an instruction. They must be;
i. positioned in close proximity to the subject of the instruction;
ii. relevant to the task;
iii. of a long wearing material.

1.3.15 Are instructions present?

YES [ ]

If no, please proceed to the next section - NO [ ]

1.3.16 If yes, what forms are they in?

WARNING [ ]
INSTRUCTION [ ]
OTHER [ ]

IF OTHER PLEASE GIVE DETAILS...

1.3.17 How are the instructions presented?

DECAL [ ]
MOULDED [ ]
OTHER [ ]

IF OTHER PLEASE GIVE DETAILS...

1.3.18 Are the instructions placed appropriately in relation to the task?

YES [ ]

IF NO, PLEASE GIVE DETAILS...

1.3.19 How well do the instructions impart the relevant information?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS...

GENERAL COMMENTS....
GENERAL CONCLUSIONS FOR THE PROBE.

Prompts: - anti-drip valve
   - the control valve
   - cleaning facilities
   - storage facilities
   - instructions/warnings.

1.4 MANUAL METHOD OF INDUCTION.

Points to be considered in relation to the manual induction of pesticides;

   i. access to the tank, these should be convenient, easy to use and safe
      (please refer to Section 8 "Access Facilities");
   ii. it is desirable for the lid to be hinged and openable using only one hand;
   iii. the position of the hinge of the lid, this should be set to one side to
        facilitate easy opening;
   iv. the diameter of the tank opening, must be not less than 34 cm (13.5");
   v. the distance between a vertical line through the centre of the opening
      and a vertical line through the nearest access point should not be greater
      than 31 cm (13.5");
   vi. room should be provided to rest containers whilst filling.

1.4.1 How easy is it to gain access to the tank(s)? (Refer to Section 8 "Access
      Facilities").
   Prompts: - handholds
          - ladders
          - platforms.

   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS..........................

   ..................................................................................................................
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GENERAL COMMENTS...................................................................................

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   ..................................................................................................................
   ..................................................................................................................
   ..................................................................................................................
   ..................................................................................................................

Contents
1.4.2 Measure the diameter of the tank opening(s).

1.4.3 What is the distance(s) from the nearest access point to the tank and a vertical line through the mid-point of the tank? (Please refer to diagram below).

1.4.4 What is the height of the tank opening(s), from the standing area surface? (Please refer to diagram below).

1.4.5 Is the lid of the tank(s) hinged?

   YES [ ]
   NO [ ]

1.4.6 How easy is the lid of the tank(s) to open with one hand?

   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS..........................

.................................................................

GENERAL COMMENTS.............................................

.................................................................

1.4.7 Is a facility provided where containers, of different sizes, may be rested during the operation?

   YES [ ]
   NO [ ]
1.4.8 Please rate the degree of difficulty in carrying containers to the pouring position?

    VERY EASY [ ]
    EASY [ ]
    ADEQUATE [ ]
    DIFFICULT [ ]
    VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS........................................

.................................................................................................................................

GENERAL COMMENTS........................................................................................................

.................................................................................................................................

OVERALL COMMENTS ABOUT THE MANUAL INDUCTION OF PESTICIDES.

Prompts: - access to the tank
    - position of the lid
    - diameter of the opening
    - removing the lid
    - containment of spillage
    - rest facilities.

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2 SPRAYER CONTROLS.

Sprayer controls come in two main varieties, depending upon the type of sprayer;

a. Remote controls, - these are operated within the confines of the cab;
b. Manual controls, - these are operated through the rear window of the cab.

In some instances, it is necessary to set the controls outside first, and then operate an overall on/off switch within the cab.

In terms of safety and efficiency, the in cab (remote) controls are most desirable and the manual controls which require operating out of the window, least desirable. When the controls are operated through the rear window, there is an increased potential for contamination, due to spray drift entering the open window, or contamination from the controls passing onto the operator's hand.

The controls must be operable by all users from a 5th percentile female to a 95th percentile male, if the controls are situated outside then a 5% allowance for PPE shall be made.

The sprayer controls generally consist of:

i. an emergency out-put kill switch;
ii. overall on/off switch, for all of the spray controls;
iii. individual controls for each segment of the boom;
iv. a control for raising and lowering the boom;
v. pressure control switch, the pressure may adjust automatically to compensate for the switching on/off of boom segments, however often a manual adjustment is often present as well.

All of the controls must:

i. be easily accessible, especially the emergency kill switch, which must be accessible from the ground or from the cab;
ii. be easily identifiable, each control's function must be clearly represented;
iii. be easy to use;
iv. conform to recognised conventions in terms of movement;

2.1 Is there an emergency out-put kill facility present?

YES [  ]

If no, please proceed to question 2.5 - NO [  ]

IF YES, PLEASE GIVE DETAILS ..........................................................................................................................
........................................................................................................................................................................
........................................................................................................................................................................

2.2 If yes, where is it situated?

IN-CAB [  ]

ON SPRAYER [  ]
2.3 How easy is the emergency kill facility to use?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.

..........................................................
..........................................................

GENERAL COMMENTS.

..........................................................
..........................................................

2.4 Does the emergency kill facility conform to recognised conventions?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS.

..........................................................
..........................................................

2.5 Is there an overall on/off switch present?

YES [ ]

If no, please proceed to question 2.9 - NO [ ]

2.6 If yes, where is it situated?

IN-CAB [ ]
ON SPRAYER [ ]

2.7 How easy is the overall on/off switch to use?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.

..........................................................
..........................................................

GENERAL COMMENTS.

..........................................................
..........................................................
2.8 Does the overall on/off switch conform to recognised conventions?

YES [ ]

NO [ ]

IF NO, PLEASE GIVE DETAILS.................................................................................................................................

.................................................................................................................................

.................................................................................................................................

2.9 Are separate boom segment controls present?

YES [ ]

If no, please proceed to question 2.13 - NO [ ]

2.10 If yes, then where are they situated?

IN-CAB [ ]

ON SPRAYER [ ]

2.11 How easy are the boom segment controls to use?

VERY EASY [ ]

EASY [ ]

ADEQUATE [ ]

DIFFICULT [ ]

VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS..................................................

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GENERAL COMMENTS.................................................................................................................................

.................................................................................................................................

.................................................................................................................................

2.12 Do the boom segment controls conform to recognised conventions?

YES [ ]

NO [ ]

IF NO, PLEASE GIVE DETAILS.................................................................................................................................

.................................................................................................................................

.................................................................................................................................

2.13 Are there separate controls for raising/lowering the booms?

YES [ ]

If no - please proceed to question 2.17 - NO [ ]

2.14 If yes, where are they situated?

IN-CAB [ ]

ON SPRAYER [ ]
2.15 How easy are the boom raising/lowering controls to use?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS

GENERAL COMMENTS

2.16 Do the boom raising/lowering controls conform to recognised conventions?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS

2.17 Is the pressure control automatic?

YES [ ]
NO [ ]

2.18 Is a pressure control switch present?

YES [ ]

If no - please proceed to question 2.22 - NO [ ]

2.19 If yes, where is it situated?

IN-CAB [ ]
ON SPRAYER [ ]

2.20 How easy is the pressure control to use?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS
GENERAL COMMENTS

2.21 Does the pressure control switch conform to recognised conventions?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS...

2.22 Are the functions of the different controls well represented?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS...

2.23 Are any further controls present?

YES [ ]
NO [ ]

IF YES, PLEASE GIVE DETAILS...

GENERAL CONCLUSIONS ABOUT THE SPRAYER CONTROLS.

Prompts - presence or absence of the controls
- placement of the controls
- ease of use of the controls
- conformity to recognised conventions
- representation of the controls functions.
3 FACILITIES ON THE SPRAYER.

Sprayer safety features are frequently offered as optional extras. Having these facilities enhances operator safety by decreasing the likelihood of contamination of the user.

The facilities that are considered necessary are;

a. Washing facilities with a means of controlling the pressure and direction of the water flow. These need to be positioned in areas where they are most likely to be needed, eg the pesticide induction area. 15 - 20 litres of water should be provided for cleaning of both the user and the equipment (please refer to section 1.1).

b. Used personal protective equipment (PPE) store - contaminated clothing should not be taken into the cab, therefore a store should be on the sprayer for the safe storage of contaminated PPE. It is desirable that the PPE store is easy to clean to prevent a build-up of chemicals occurring.

c. Spare uncontaminated equipment store - for the storage of spare PPE, nozzles, filters and so forth. Once an article has been removed from this store and used, it must not be returned to it.

d. Pesticide container store - On occasions pesticides are taken to the spraying area. It is vital that these containers are stored properly in a firmly attached, lockable, store.

e. First aid kit - for emergencies, this should be located on the sprayer where it is easily accessible from the ground.

It is important that all of the above facilities have sealed lids to prevent any spray from entering. They should all be easy to open and close and be accessible to a range of people from a 5th percentile female to a 95th percentile male wearing PPE.

3.1 WASHING FACILITIES.

Please refer to Section 1.1

3.2 USED PPE STORE.

This store should be;

i. positioned close to the cab for convenience

ii. easily accessible

iii. sealed against spray drift

iv. easy to clean to prevent pesticide build-up.

3.2.1 Is a used PPE store offered as:

STANDARD [ ]

OPTIONAL [ ]

If not available, please proceed to section 3.3 - NOT AVAILABLE [ ]
3.2.2 How easy is it to gain access to the PPE store?
   Prompts - relative position
   - lid opening.

   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

   IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS
   ........................................................................................................
   ........................................................................................................
   GENERAL COMMENTS...........................................................................
   ........................................................................................................
   ........................................................................................................
   ........................................................................................................

3.2.3 Is a seal present in the lid of the store?

   YES [ ]
   NO [ ]

3.2.4 How easy would it be to clean the store?

   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

   IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS
   ........................................................................................................
   ........................................................................................................
   GENERAL COMMENTS...........................................................................
   ........................................................................................................
   ........................................................................................................
   ........................................................................................................

OVERALL CONCLUSIONS ABOUT THE PPE STORE.

Prompts - access
   - seal
   - ease to clean.

........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
3.3 SPARE UNCONTAMINATED EQUIPMENT STORE.

It is not always appropriate to carry spare equipment in the cab for reasons of inconvenience, or damage occurring to the equipment. Therefore a spare uncontaminated equipment store is desirable. This should:

i. be easy to gain access into;
ii. be sealed to prevent contamination of the equipment;
iii. positioned in a convenient location.

3.3.1 Is a spare equipment store offered as?

STANDARD [ ]

OPTIONAL [ ]

If not available, please proceed to section 3.4 - NOT AVAILABLE [ ]

3.3.2 How easy is it to gain access to the spare equipment store?

Prompts - relative position of the store
- lid opening

VERY EASY [ ]

EASY [ ]

ADEQUATE [ ]

DIFFICULT [ ]

VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS...................

..............................................................................................................................

..............................................................................................................................

3.3.3 Is a seal present in the lid of the store?

YES [ ]

NO [ ]

3.3.4 How easy would it be to clean the store?

VERY EASY [ ]

EASY [ ]

ADEQUATE [ ]

DIFFICULT [ ]

VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS...................

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GENERAL COMMENTS

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..............................................................................................................................
OVERALL CONCLUSIONS ABOUT THE UNCONTAMINATED EQUIPMENT STORE.

Prompts - access
- seal
- ease to clean.

3.4 PESTICIDE CONTAINER STORE.

If pesticide containers are to be carried on the sprayer, then appropriate storage facilities must be provided. The store must;

i. be firmly attached to the sprayer;
ii. be lockable;
iii. have a sump present;
iv. be easily opened;
v. fit a variety of different pesticide containers;
vi. be easy to clean.

3.4.1 Is a pesticide container store offered as?

STANDARD [ ]
OPTIONAL [ ]

If not available, please proceed to section 3.5 - NOT AVAILABLE [ ]

3.4.2 Is the store firmly attached to the sprayer?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS.

3.4.3 Is the pesticide store lockable?

YES [ ]
NO [ ]

PLEASE GIVE DETAILS.

3.4.4 Does the store have a sump?

YES [ ]
NO [ ]
3.4.5 How easy is it to gain access to the store?
   - relative position of the store
     - lid opening.

   \[ \begin{array}{l}
   \text{VERY EASY [ ]} \\
   \text{EASY [ ]} \\
   \text{ADEQUATE [ ]} \\
   \text{DIFFICULT [ ]} \\
   \text{VERY DIFFICULT [ ]}
   \end{array} \]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS..............................................

3.4.6 Will a variety of pesticide container shapes fit into the pesticide store?

   \[ \begin{array}{l}
   \text{YES [ ]} \\
   \text{NO [ ]}
   \end{array} \]

3.4.7 How easy would the store be to clean?

   \[ \begin{array}{l}
   \text{VERY EASY [ ]} \\
   \text{EASY [ ]} \\
   \text{ADEQUATE [ ]} \\
   \text{DIFFICULT [ ]} \\
   \text{VERY DIFFICULT [ ]}
   \end{array} \]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS..............................................

Instructions should be present for the safe use of the pesticide container store. It is desirable for these to be in the form of either a warning or in the form of an instruction. They must be;

i. positioned in close proximity to the subject of the instruction;
ii. appropriate;
iii. of a long wearing material.

3.4.8 Are instructions present?

   \[ \begin{array}{l}
   \text{YES [ ]} \\
   \text{NO [ ]}
   \end{array} \]

   If no, please proceed to conclusions for section - NO [ ]

3.4.9 If yes, what forms are they in?

   \[ \begin{array}{l}
   \text{WARNING [ ]} \\
   \text{INSTRUCTION [ ]} \\
   \text{OTHER [ ]}
   \end{array} \]
3.4.10 How are the instructions presented?

DECAL [ ]
MOULDED [ ]
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS.

3.4.11 How well are they placed in relation to the task?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS.

3.4.12 How well do the instructions impart the relevant information?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS.

GENERAL COMMENTS.
OVERALL CONCLUSIONS ABOUT THE PESTICIDE CONTAINER STORE.

Prompts - attachment to unit
    - lockable
    - sump
    - access
    - container shapes
    - ease to clean
    - instructions

3.5 FIRST AID KIT.
The first aid kit must be:

   i. sealed;
   ii. accessible from the ground;
   iii. easy to open;

3.5.1 Is a first aid kit present?  YES [ ]

   If no, please proceed to section 4 - NO [ ]

3.5.2 Describe where the first aid kit is located?
    Prompts - position
        - access
        - hazards

3.5.3 Is the first aid kit sealed from the spray?  YES [ ]

   NO [ ]

OVERALL CONCLUSIONS..........................................................................................................................
4. BOOM HANDLING.

Two methods of boom handling are used depending upon the size and the cost of the sprayer unit:

a. Remote - either by hydraulic and/or pneumatic mechanisms, that are electrically operated from the cab.
b. Manually - this method is generally used for booms that are 12 m or less, and requires the operator to manually open/close the booms. A problem with this process is often the booms do not remain level after one side has been opened or closed, making the opening or closing of the other side more difficult.

Introduced recently is the front mounted boom, this allows for increased stability of the spraying unit. However, there is a concern that the user is then driving through the spray.

On the larger sprayers, opening of automatic booms close to power lines is another source of potential danger. For this reason it is recommended that the booms are designed such that they will not open above five metres.

Storage of the booms may present a problem. The longer booms are frequently stored folded along the sides of the spray unit, which:

a. sometimes results in the entrance to the cab being obstructed;
b. may expose the operator to droplets of spray from the booms when entering/exiting the cab;
c. protrusions may present a potential hazard to the operator as he enter/exits the cab.

Therefore, it is desirable that the booms do not fold around the cab area.

4.1 How are the booms controlled?

REMTELY [ ]
MANUALLY [ ]
BOTH [ ]

4.1 REMOTE BOOMS.

4.1.2 How are the booms stored?

FOLDED ALONG THE SIDES [ ]
FOLDED ACROSS THE BACK [ ]
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS...........................................................................................................
4.1.3 If the booms fold along the sides, would they obstruct the entrance to the cab?

YES [ ]

NO [ ]

COMMENTS..............................................................................................................................

..............................................................................................................................

4.1.4 Is there danger of droplets of pesticide hitting the operator as he operates any of the equipment on the sprayer?

YES [ ]

NO [ ]

IF YES, PLEASE GIVE DETAILS.

Prompts - alighting from cab
- water container
- induction bowl
- probe
- equipment stores
- drain tap

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..............................................................................................................................

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4.1.5 Do any protrusions from the boom present a potential hazard to the operator when in the store position?

YES [ ]

NO [ ]

IF YES, PLEASE GIVE DETAILS..................................................................................................................

..............................................................................................................................

..............................................................................................................................

4.1.6 What is the maximum height the booms can reach whilst being opened?.............

..............................................................................................................................

..............................................................................................................................

..............................................................................................................................

OVERALL CONCLUSIONS ABOUT THE REMOTE BOOMS.

Prompts - storage of the booms
- dripping from the boom
- potential hazards
- opening height.

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..............................................................................................................................

..............................................................................................................................
4.2 MANUAL BOOMS:

Points to be considered in regard to the manual operation of the booms:

i. any fastening mechanisms for the booms must be easily accessible and unfastenable;
ii. undue force should not be required to open or close the booms;
iii. the booms should remain horizontal throughout the entire opening and closing process;
iv. no potential for injury should be present, e.g. pinch points.

4.2.1 When stored, are the booms fastened shut?

YES [ ]

NO [ ]

4.2.2 If yes, is access easily gained to the fastening mechanisms for the booms?

YES [ ]

NO [ ]

4.2.3 Are the fastenings easy to use?

YES [ ]

NO [ ]

IF NO, PLEASE GIVE DETAILS...


4.2.4 Do the booms remain horizontal whilst being opened or closed?

YES [ ]

NO [ ]

4.2.5 How easy are the booms to unfold?

VERY EASY [ ]

EASY [ ]

ADEQUATE [ ]

DIFFICULT [ ]

VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS...


GENERAL COMMENTS...


4.2.6 How easy are the booms to refold?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS

GENERAL COMMENTS

4.2.7 Is there potential for injury from the booms?
Prompts - pinch points
- musculo-skeletal problems due to weight
- problems due to working angles.

YES [ ]
NO [ ]

Instructions should be present for the safe operation of the booms. It is desirable for these to be in the form of either a warning or in the form of an instruction. They must be;

i. positioned in close proximity to the subject of the instruction;
ii. appropriate;
iii. of a long wearing material.

4.2.8 Are instructions present?

YES [ ]

If no, please proceed to conclusions for section - NO [ ]

4.2.9 If yes, what forms are they in?

WARNING [ ]
INSTRUCTION [ ]
OTHER [ ]

IF OTHER PLEASE SPECIFY

4.2.10 How are the instructions presented?

DECAL [ ]
MOULDED [ ]
OTHER [ ]
4.2.11 How well are they placed in relation to the task?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS.

GENERAL COMMENTS.

4.2.13 How well do the instructions impart the relevant information?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS.

GENERAL COMMENTS.

GENERAL CONCLUSIONS ABOUT THE MANUAL BOOMS.

Prompts - fastening mechanism(s)
- ease of use
- potential hazards
- instructions/warnings
5 SPRAYER EQUIPMENT.

Standard sprayer equipment tends to be kept to a minimum, with some safety features only offered as optional extras.

The safety features that are desirable on all sprayers are;

a. nozzles - anti-drip
   - method of altering nozzle size
   - ease of replacement
b. filters - placement of filters
   - self-flushing facilities
   - accessibility
   - ease of removal and replacement
c. pump - positively located
   - accessibility
d. hose clips - ability to adjust

All of the following must be used with ease by individuals ranging in size between a 5th percentile female to 95th percentile male with an allowance for PPE.

5.1 NOZZLES.

The nozzles should have;

i. anti-drip valves. Diaphragm check type are preferable to spring and ball valves as these require less pressure to prevent dripping;
ii. a system to decrease handling when altering nozzle size, therefore systems with swivelling heads or dual boom systems are preferable to those which require manual removal and replacement;
iii. a simple quarter turn twist on/off system to replace a nozzle if required.

5.1.1 Are anti-drip valves standard fitments?

YES [ ]
NO [ ]

5.1.2 If yes, are they;

DIAPHRAGM CHECK VALVES [ ]
SPRING AND BALL VALVES [ ]
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS...

5.1.3 Please indicate if any of the following systems are present,

<table>
<thead>
<tr>
<th>STANDARD.</th>
<th>OPTIONAL.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWIVELLING HEADS.</td>
<td>[ ]</td>
</tr>
<tr>
<td>DUAL BOOM SYSTEM.</td>
<td>[ ]</td>
</tr>
<tr>
<td>OTHER.</td>
<td>[ ]</td>
</tr>
</tbody>
</table>
IF OTHER, PLEASE GIVE DETAILS.

5.1.4 Are the nozzles easy to replace?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS.

OVERALL CONCLUSIONS ABOUT THE NOZZLES.

prompt - anti-drip
- changing of nozzle size
- replacement of nozzles.

5.2 THE PUMP.

The pump should be;

i. positively located on the spray unit to prevent movement and resultant damage;
ii. accessible for maintenance and/or cleaning.

5.2.1 Is the pump positively located on the unit?

YES [ ]
NO [ ]

IF NO, PLEASE DESCRIBE THE METHOD OF ATTACHMENT.

5.2.2 How accessible is the pump for maintenance and/or cleaning?

VERY ACCESSIBLE [ ]
ACCESSIBLE [ ]
ADEQUATE [ ]
INACCESSIBLE [ ]
VERY INACCESSIBLE [ ]
IF RATED INACCESSIBLE OR VERY INACCESSIBLE, PLEASE GIVE DETAILS........

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GENERAL COMMENTS............................................................................................

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OVERALL CONCLUSIONS ABOUT THE PUMP.

Prompt - positively located
   - accessibility

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..........................................................................................................................

..........................................................................................................................

5.3 HOSE CLIPS.

It is desirable that these are able to be adjusted should the need arise.

5.3.1 What type of hose clip is present?..............................................................

..........................................................................................................................

..........................................................................................................................
6 THE CAB (SELF PROPELLED VEHICLES ONLY).

Once the spraying operation is under way, the operator will be spending a large amount of time in the cab unit. It is important that he is comfortable, safe, and able to perform his work to the best of his ability. To achieve this the following are required:

i. a forced air filtration system - to prevent spray drift entering the cab;
ii. air conditioning - the majority of spraying is performed under warm climatic conditions, an enclosed cab without air conditioning may impose an unacceptably high level of thermal stress upon the user;
iii. good visibility - to avoid accidents, good visibility is required from a comfortable driving position. It is desirable to have a clear view of the tips of the booms, of the area the booms are about to cover and the ground in front of the cab, whilst also being able to see and reach the controls and displays for the operation of the spray unit;
iv. easy access to the cab - as previously mentioned in Section 4.1 “Boom Handling”.

There is a standard cab, called a "Q" cab which fulfils the above requirements, and is being fitted to most of the self-propelled vehicles being produced now.

6.1 Is the cab a "Q" cab?

YES [ ]

NO [ ]

6.2 Is a forced air filtration system present in the cab?

YES [ ]

NO [ ]

6.3 Is the cab air-conditioned?

YES [ ]

NO [ ]

6.4 How would you rate the visibility from the cab?

VERY GOOD [ ]

GOOD [ ]

ADEQUATE [ ]

POOR [ ]

VERY POOR [ ]

IF RATED POOR OR VERY POOR, PLEASE GIVE DETAILS...

..........................................................................................................................
..........................................................................................................................

GENERAL COMMENTS...

..........................................................................................................................
..........................................................................................................................
6.5 Is there easy access into the cab?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS........................................................................................................
........................................................................................................................................
........................................................................................................................................

Instructions should be present for the safe and efficient use of the cab. It is desirable for these to be in the form of either a warning or in the form of an instruction. They must be;

i. positioned in close proximity to the subject of the instruction;
ii. appropriate;
iii. of a long wearing material.

6.6 Are instructions present?

YES [ ]

If no, please proceed to conclusions for section - NO [ ]

6.7 If yes, what forms are they in?

WARNING [ ]
INSTRUCTION [ ]
OTHER [ ]

IF OTHER PLEASE SPECIFY........................................................................................................
........................................................................................................................................
........................................................................................................................................

6.8 How are the instructions presented?

DECAL [ ]
MOULDED [ ]
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS...................................................................................................
........................................................................................................................................
........................................................................................................................................

6.9 How well are they placed in relation to the task?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]
6.11 How well do the instructions impart the relevant information?

   VERY WELL [ ]
   WELL [ ]
   ADEQUATE [ ]
   POOR [ ]
   VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS

GENERAL COMMENTS

GENERAL CONCLUSIONS ABOUT THE CAB.

Prompts - air filtration
- air conditioning
- visibility
- access
- instructions/warnings.
7 TANK FACILITIES.

If using the manual method of inducting pesticides, then the tank should meet certain criteria, please refer to section 1.4 "Pesticide Filling Facilities - Manual Method".

Additional features which are important with regard to the tank are;

a. The contents gauge;
b. Drainage facility;
c. Baffles within the tank.

7.1 DRAINAGE OF THE TANK.

A drain tap is required for the removal of waste pesticide solutions. It is desirable that this is:

i. accessible, the tap should be easy to reach;
ii. be located so that no part of the user is at risk of contamination whilst operating it;
iii. be easily, (eg in poor light), and permanently identifiable as to the functions of the valve (ie which position is on, and which position is off);
iv. conform to recognised conventions;
v. be easily operable thus avoiding undue exertion by the operator.

7.1.1 Describe the location of the drain tap
Prompts - height
- accessibility
- ease of use
- obstructions

7.1.2 When using the drain tap, is the user exposed to any potential hazards from other pieces of equipment?

YES [ ]  
NO [ ]

IF YES, PLEASE GIVE DETAILS...

7.1.3 Are the on/off positions of the control valves easily identifiable?

YES [ ]  
NO [ ]
7.1.4 Does the operation of the drain tap conform to recognised conventions?

YES [ ]
NO [ ]

7.1.5 How easy is the drain tap to use with one hand?

VERY EASY [ ]
EASY [ ]
Adequate [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS

GENERAL COMMENTS


Instructions should be present for the safe and efficient use of the drainage tap. It is desirable for these to be in the form of either a warning or in the form of an instruction. They must be:

i. positioned in close proximity to the subject of the instruction;
ii. appropriate;
iii. of a long wearing material.

7.1.6 Are instructions present?

YES [ ]

If no, please proceed to conclusions for section - NO [ ]

7.1.7 If yes, what forms are they in?

WARNING [ ]
INSTRUCTION [ ]
OTHER [ ]
7.1.8 How are the instructions presented?

DECAL [ ]
MOULDED [ ]
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS

7.1.9 How well are they placed in relation to the task?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS

7.1.10 How well do the instructions impart the relevant information?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS

GENERAL COMMENTS...
OVERALL CONCLUSIONS ABOUT THE DRAINAGE OF THE TANK.

Prompts - location
- potential hazards
- controls
- ease of use
- instructions/warnings.

7.2 THE CONTENTS GAUGE.

The contents gauge is nearly always displayed in one or other of the following forms;

   a. Decal;
   b. Embossed.

It is desirable that the contents gauge is;

   i. accurate, there may be errors in both varieties of gauges, however the
      adhesive variety tends to be the least accurate;
   ii. permanent, adhesive labelling generally has a relatively short
       life-span, with implications for inappropriate dosing;
   iii. easy to read, with good contrast between the gauge and it’s
       background;
   iv. interpretable, the gauge should have clearly marked divisions, with
       both metric and imperial scales.

7.2.1 What variety of contents gauge is present?

   DECAL [ ]
   EMBOSSED [ ]
   OTHER [ ]

IF OTHER, PLEASE SPECIFY

7.2.2 How easy is the gauge to read?

   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]
7.2.3 How easy is the gauge to interpret?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

7.2.4 Are scaled divisions presented in:

METRIC [ ]
IMPERIAL [ ]
BOTH [ ]

OVERALL CONCLUSIONS ABOUT THE CONTENTS GAUGE.
Prompts - variety
- readable
- interpretable
- scales

7.3 BAFFLES.

Baffles are required to improve the stability of sprayers by restricting the movement of the pesticide solution.

7.3.1 Are baffles present?

YES [ ]
NO [ ]
8 ACCESS FACILITIES.

On occasions, it is necessary to climb up onto the sprayer unit. This can be for:

   a. induction of pesticides, if using the manual method of induction;
   b. cleaning purposes;
   c. maintenance purposes.

To facilitate easy access, handholds, ladders and platforms may be required.

For manual induction of pesticides, it is often necessary to use two hands to pour the pesticides out at shoulder height. Therefore adequate access facilities must be provided. It is envisaged that the manual induction of chemicals will eventually become obsolete now that alternative methods are available.

It should be remembered that the wearing of PPE will limit the level of dexterity and manoeuvrability when climbing aboard the sprayer.

Users ranging in size from a 5th percentile female to a 95th percentile male must be able to gain access onto the sprayer when required.

8.1 HANDHOLDS.

Handholds should be;

   i. located in functional positions;
   ii. appropriate to the task;
   iii. of the correct anthropometric dimensions.

![Handhold Diagram]

Min. 2.0 cm (0.8")
Min. 11 cm (4.5")
Min. 4.75 cm (1.9")

8.1.1 Are handholds necessary?

   YES [ ]
   NO [ ]

COMMENTS........................................................................................................................................

........................................................................................................................................

........................................................................................................................................
8.1.2 Are there handholds present?

YES [ ]

If no, please proceed to section 8.2 - NO [ ]

COMMENTS...


8.1.3 How well are the handholds functionally located?

VERY WELL [ ]

WELL [ ]

ADEQUATE [ ]

POOR [ ]

VERY POOR [ ]

IF RATED POOR OR VERY POOR, PLEASE GIVE DETAILS...


GENERAL COMMENTS...


8.1.4 Are an adequate number of handholds present?

YES [ ]

NO [ ]

IF NO, PLEASE GIVE DETAILS...


8.1.5 Are the handholds of the correct anthropometric dimensions? (please refer to diagram above.
Prompts - length of handhold
- width of grip
- finger clearance.

YES [ ]

NO [ ]

IF NO, PLEASE GIVE DETAILS...


OVERALL CONCLUSIONS ABOUT THE HANDHOLDS.

Prompts - location
  - number
  - anthropometric data
  - functional utility.

8.2 LADDERS.

These are necessary for any step up above 50 cm. It is desirable that the ladders;

  i. conform to the correct anthropometric data;
  ii. are not going to cause a potential hazard by protrusion of any part;
  iii. have a non-slip surface.

If the ladder is to be folded, then it must have a means of being secured shut, which must also be easy to operate.

8.2.1 Are stepladder(s) necessary? (if initial step is greater than 50 cm).

YES [ ]
NO [ ]

COMMENTS

8.2.2 Are stepladder(s) present?

YES [ ]

If no, please proceed to section 8.3 - NO [ ]

COMMENTS

8.2.3 What is the height of the initial step?
8.2.4 Do the stepladder(s) conform to the following anthropometric data?

48.5 - 61.0 cm
(19 - 24")

30.5 - 43.5 cm
(12 - 17")

GRIPS.
Rounded.
Not square.

YES [ ]
NO [ ]

8.2.5 Does the ladder(s) present a potential hazard by protrusion?

YES [ ]
NO [ ]

IF YES, PLEASE GIVE DETAILS.

8.2.6 Are the steps of the ladder a non-slip surface?

YES [ ]
NO [ ]

8.2.7 Is the ladder detachable?

YES [ ]

If no, please go to 8.2.10 - NO [ ]

8.2.8 If yes, are adequate storage facilities available?

YES [ ]
NO [ ]

8.2.9 How easy is the ladder to use?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.
GENERAL COMMENTS

8.2.10 Does the ladder fold?

YES [ ]
If no, please go to section 8.3 - NO [ ]

8.2.11 If yes, is the ladder able to be secured when shut?

YES [ ]

NO [ ]

8.2.12 How easy is the ladder to store?

VERY EASY [ ]

EASY [ ]

ADEQUATE [ ]

DIFFICULT [ ]

VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS

GENERAL COMMENTS

OVERALL CONCLUSIONS ABOUT THE LADDER(S).

Prompts - anthropometric data
- potential hazard
- non-slip surfaces
- method of storage and ease of use.

8.3 PLATFORMS.

Platforms may be required to gain access to perform certain tasks on the sprayer.

Platforms should;

i. be adequate to perform the necessary task;
ii. have a non-slip surface;
iii. not contain any spillage.
8.3.1 Is / are platform(s) necessary?

YES [ ]
NO [ ]

COMMENTS: .................................................................
............................................................................
............................................................................

8.3.2 Is / are there platform(s) present?

YES [ ]

If no, please proceed to section 9 - NO [ ]

COMMENTS: .................................................................
............................................................................
............................................................................

8.3.3 Is the platform(s) sufficient to perform the task?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS: ...........................................
............................................................................
............................................................................

8.3.4 Please draw the platform with the relevant dimensions (width, length etc).

8.3.4 Is / are the surface of the platform(s) non-slip?

YES [ ]
NO [ ]

8.3.5 Would any spillage be contained on the platform?

YES [ ]
NO [ ]
OVERALL CONCLUSIONS ABOUT THE PLATFORMS

Prompts - appropriate to task
  - non-slip surface
  - spillage.
9 HAZARD WARNINGS AND INSTRUCTIONS.

This section is designed to cover the warnings and instructions that have not been included in the individual sections.

Hazard warnings and instructions are required to draw attention to areas that are potentially hazardous, or require explanation for the operator. These should be;

a. Situated as close as possible to the potential hazard or task site.

b. Permanent - therefore the adhesive variety are not entirely satisfactory due to their relatively short life-span.

c. Clear - they should be short and explicit.

d. Understandable to all users - if the sprayer is expected to be sold through-out Europe, then the warnings and instructions must be so designed that all user groups can understand them.

9.1 Are there warnings and/or instructions present, that have not already been included in previous sections?

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>WARNINGS</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>INSTRUCTIONS</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

If no to both of these, please continue to the final page.

9.2 If yes, how are they presented?

<table>
<thead>
<tr>
<th></th>
<th>DECAL</th>
<th>MOULDED</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>WARNINGS</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>INSTRUCTIONS</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

IF OTHER, PLEASE GIVE DETAILS.................................................................

......................................................................................................................

......................................................................................................................

9.3 Generally, how well are the warnings and instructions positioned in relation to the points of potential hazard or the task site?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VERY WELL</td>
<td>[ ]</td>
</tr>
<tr>
<td>WELL</td>
<td>[ ]</td>
</tr>
<tr>
<td>ADEQUATE</td>
<td>[ ]</td>
</tr>
<tr>
<td>POOR</td>
<td>[ ]</td>
</tr>
<tr>
<td>VERY POOR</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

IF RATED POOR OR VERY POOR, PLEASE GIVE DETAILS........................................

......................................................................................................................

......................................................................................................................
9.4 How well is the relevant information imparted?

<table>
<thead>
<tr>
<th>Rating</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VERY WELL</td>
<td>[ ]</td>
</tr>
<tr>
<td>WELL</td>
<td>[ ]</td>
</tr>
<tr>
<td>ADEQUATE</td>
<td>[ ]</td>
</tr>
<tr>
<td>POOR</td>
<td>[ ]</td>
</tr>
<tr>
<td>VERY POOR</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

IF RATED POOR OR VERY POOR, PLEASE GIVE DETAILS

GENERAL COMMENTS

OVERALL CONCLUSIONS ABOUT THE HAZARD WARNINGS AND INSTRUCTIONS.

Prompts - presence/absence of warnings and instructions
  - portrayal of hazard
  - positioning
  - relevance of information
TESTING OF THE SPRAYERS.
Please note the results of any ergonomic, performance or safety tests that have been conducted for any part of this model/model range.

UNIQUE DESIGNS OR NEW INNOVATIONS.
Please give details of any unique design features or new innovations for this model/model range, that is not typical of other manufacturers spray units.

OVERALL CONCLUSIONS ABOUT THE MODEL/MODEL RANGE.
Appendix 2

Questionnaire for manufacturers of field crop sprayers

Company name: ..................................................................................................................

The aim of this questionnaire is to assess the attitudes of those who manufacture/import crop sprayers, regarding safety and ergonomic design.

1.0 Induction

1.1 Please identify the models/model range(s) of field crop sprayer which you produce; please indicate type (mounted, trailed, demountable, self-propelled)

<table>
<thead>
<tr>
<th>Models/model range(s)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
</tr>
<tr>
<td>e</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td></td>
</tr>
</tbody>
</table>

1.2 Can you give details of approximate sales figures for the sprayers you produce?

Yes [ ]
No [ ]

If 'Yes' a >50
b 50 - 150
c 500 - 1000
d >1000

<table>
<thead>
<tr>
<th>Models/model range(s)</th>
<th>UK</th>
<th>Europe</th>
<th>Rest of the World</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td></td>
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<tr>
<td>c</td>
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<tr>
<td>f</td>
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</tr>
</tbody>
</table>
1.3 Please state whether the following items of equipment are fitted as standard, optional or not available for each of the ranges of sprayer which you produce:

<table>
<thead>
<tr>
<th>Model/model range (a)</th>
<th>Std</th>
<th>O/E</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction probe (with metering device)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induction probe (without metering device)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low level induction hopper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed system induction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing facilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean PPE store</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dirty PPE store</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Container Washer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-cab boom controls: raise/lower fold</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model/model range (b)</th>
<th>Std</th>
<th>O/E</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction probe (with metering device)</td>
<td></td>
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<tr>
<td>Induction probe (without metering device)</td>
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<td></td>
</tr>
<tr>
<td>Low level induction hopper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed system induction</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Washing facilities</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Clean PPE store</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Dirty PPE store</td>
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<td></td>
<td></td>
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<tr>
<td>Container Washer</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>In-cab boom controls: raise/lower fold</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model/model range (c)</td>
<td>Std</td>
<td>O/E</td>
<td>N/A</td>
</tr>
<tr>
<td>-----------------------</td>
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</tr>
<tr>
<td>Induction probe (with metering device)</td>
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<tr>
<td>Induction probe (without metering device)</td>
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<tr>
<td>Low level induction hopper</td>
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<tr>
<td>Closed system induction</td>
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<td></td>
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<tr>
<td>Washing facilities</td>
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<td></td>
<td></td>
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<tr>
<td>Clean PPE store</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Dirty PPE store</td>
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<tr>
<td>Container Washer</td>
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<td></td>
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</tr>
<tr>
<td>In-cab boom controls: raise/lower</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>fold</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Model/model range (d)</th>
<th>Std</th>
<th>O/E</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction probe (with metering device)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induction probe (without metering device)</td>
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<td></td>
</tr>
<tr>
<td>Low level induction hopper</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Closed system induction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing facilities</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Clean PPE store</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Dirty PPE store</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Container Washer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-cab boom controls: raise/lower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fold</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model/model range (e)</td>
<td>Std</td>
<td>O/E</td>
<td>N/A</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----</td>
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</tr>
<tr>
<td>Induction probe (with metering device)</td>
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<tr>
<td>Induction probe (without metering device)</td>
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<td></td>
</tr>
<tr>
<td>Low level induction hopper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed system induction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing facilities</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Clean PPE store</td>
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<tr>
<td>Dirty PPE store</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Container Washer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-cab boom controls : raise/lower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fold</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model/model range (f)</th>
<th>Std</th>
<th>O/E</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction probe (with metering device)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induction probe (without metering device)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low level induction hopper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed system induction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing facilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean PPE store</td>
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<td></td>
<td></td>
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<tr>
<td>Dirty PPE store</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Container Washer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-cab boom controls : raise/lower</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fold</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.4 Closed systems
1.4.1 Are any of the sprayer models/model ranges which you market fitted with a 'closed induction system'?

Yes [ ]  
No [ ]

If 'Yes' please describe the features of this system(s)
________________________________________
________________________________________
________________________________________
If 'No' have you any plans for the introduction of a 'closed induction system'?  

Yes [ ]  
No [ ]

If 'Yes' can you give an approximate date for when you hope to market this system?
________________________________________

Which model/model range(s) is it designed to be used in conjunction with?
________________________________________
________________________________________
________________________________________
Will the 'closed system' be fitted to these sprayers as standard equipment or as an optional extra?

<table>
<thead>
<tr>
<th>Model/model range(s)</th>
<th>Std</th>
<th>O/E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

If 'No' please give reasons for not introducing a 'closed induction system'

<table>
<thead>
<tr>
<th>Reason</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
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</tbody>
</table>

1.5 Self propelled sprayers

1.5.1 Are any of the sprayer models/model ranges which you market fitted with a forced air filtration system?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

If 'Yes' please state which models/model range(s)

<table>
<thead>
<tr>
<th>Models/model range(s)</th>
<th>Std</th>
<th>O/E</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>

6
1.5.2 Has this system been tested and referenced to an appropriate standard?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

If ‘Yes’ please give details of any testing carried out


1.6 Do any of your sprayers have any safety features which you consider to be either unique or highly desirable?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

If ‘Yes’ please give details

<table>
<thead>
<tr>
<th>Models/model range(s)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>
1.7 Do you have any plans for the introduction of any safety innovations relating to pesticide induction for the sprayers you produce?

Yes □
No □

If 'Yes' please give details

<table>
<thead>
<tr>
<th>Models/model range(s)</th>
<th>Safety feature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

1.8 For any of the models/model range(s) of sprayer which you produce, are pesticide supply pipes designed to be directed through the cab?

Yes □
No □

If 'Yes' please state appropriate models/model range(s)

________________________________________

________________________________________

________________________________________

________________________________________
1.9 For each of the models/model ranges of sprayer which you produce, please give details of which have a manual and which have automatic boom folding facility fitted

<table>
<thead>
<tr>
<th>Model/model range(s)</th>
<th>Std</th>
<th>O/E</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td></td>
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<tr>
<td>c</td>
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<tr>
<td>e</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.0 Instructions and warnings

2.1 Are there any inherent hazards associated with the type of products which you produce/market which you feel you need to warn the user about?

<table>
<thead>
<tr>
<th>Models/model range(s)</th>
<th>Hazard</th>
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Comments

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2.1.1 Are these potential hazards brought to the attention of the user?

- Yes [ ]
- No  [ ]
If 'Yes' which warning method(s) do you use?

- Warning labels on the sprayer
- Warnings in instruction leaflets or booklets
- other (please state)

**NB**: obtain examples

**2.1.2** Does the information provided inform the user regarding how the hazard should be dealt with?

- Yes
- No

If 'Yes' which warning method(s) do you use?

- Labels on the sprayer
- Instruction leaflets or booklets
- other (please state)

**NB**: obtain examples

**2.1.3** Have you taken any steps to remove any of these hazards through the imposition of engineering controls?

- Yes
- No

If 'Yes' please give details

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
2.1.4 Does the information you provide inform the user regarding appropriate action in the event of an accident involving spillage or contamination from pesticide?

- Yes
- No

If 'Yes' which method(s) do you use?

- Labels on the sprayer
- Instruction leaflets or booklets
- Other (please state)

**NB:** obtain examples

2.1.5 In which countries do you market your sprayers?

<table>
<thead>
<tr>
<th>Models/model range(s)</th>
<th>Country</th>
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2.1.6 Which languages are used for your product markings and instruction booklets?

<table>
<thead>
<tr>
<th>Product markings</th>
<th>Instruction booklets</th>
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<tbody>
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</table>
3.0 Training courses

3.1 Do you provide any training courses for users of the equipment you produce?

<table>
<thead>
<tr>
<th>Models/model range(s)</th>
<th>Duration</th>
<th>Content</th>
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4.0 Safe practice

4.1 Please give details of the aspect of pesticide use which you consider poses the greatest potential risk to the user, (please give reasons)

<table>
<thead>
<tr>
<th>Task</th>
<th>Risk</th>
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4.2 What do you think the most significant safety innovation would be - in relation to which process? (Please give details)

<table>
<thead>
<tr>
<th>Task</th>
<th>Innovation</th>
</tr>
</thead>
<tbody>
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</table>
5.0 Legislation

5.1 Can you give details of the legislative changes brought about by the introduction of the C.O.S.H.H. regulations?

Yes ☐
No ☐

If 'Yes' please give details
_____________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________

5.2 What do you consider to be the most significant aspects of the C.O.S.H.H. legislation are, with specific reference to its implications for you as a manufacturer/importer?

Please give details
_____________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________
_____________________________________________________________________________________________________________________

5.3 Has the C.O.S.H.H. legislation led to the revision or alteration of any of the design features of any of the products which you produce?

Yes ☐
No ☐

If 'Yes' please give details; stating - model/model range(s); type of modifications

<table>
<thead>
<tr>
<th>C.O.S.H.H. requirement</th>
<th>Model/model range(s)</th>
<th>Revision/alteration</th>
</tr>
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</table>
5.4 Do you think that current legislation, relating to the construction and use of pesticide sprayers, should be changed or modified in any way(s)?

Yes [ ]
No [ ]

If 'Yes' please give details

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

6.0 The market

6.1 Please place in order of priority the level of importance which you believe purchasers place upon the following criteria when selecting a sprayer

Place a number against each issue

1 purchase price
2 operator safety
3 application efficiency
4 speed of application
5 ease of maintenance
6 durability
7 reliability
8 quality of service from manufacturer/supplier
9 spares availability

6.2 Do you think that the attitude of potential purchasers towards safety has changed significantly in recent years?

Yes [ ]
No [ ]
If 'Yes' please give details of any changes as you perceive them


6.2.1 Has this influenced you in terms of design?

Yes ☐
No ☐

If 'Yes' in what way(s) - please give examples


Appendix 3

CHECKLIST FOR CLOSED SYSTEMS

This checklist includes changes to Appendix 2 as applied to closed systems

1.1 WATER SUPPLY.

A clean water supply should be present, mounted on the sprayer. Sufficient water (recommended 15 - 20 litres) is required for decontamination of:

i. the operator;
ii. PPE;
iii. measuring containers;
iv. contaminated parts of the sprayer;
v. equipment, eg nozzles.

The pressure and direction of the water flow should be controllable. For example, a rinsing gun and hose attachment to the water supply allows more freedom of use.

1.1.1 Is a clean water supply available separate to the main tank?

as standard - YES [ ]

If no, please proceed to 1.1.4 - NO [ ]

1.1.2 If yes, what is its capacity, in litres? .................................................................

.................................................................

1.1.3 Please describe the position of the water supply, and note any hazards present.

..........................................................................................................

..........................................................................................................

..........................................................................................................

..........................................................................................................

1.1.4 If no, is a tap provided on the main water tank?

YES [ ]

NO [ ]
1.1.5 How easy is the water to use in the cleansing of:

<table>
<thead>
<tr>
<th>V. EASY</th>
<th>EASY</th>
<th>ADEQUATE</th>
<th>DIFFICULT</th>
<th>V. DIFFICULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>The operator;</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>PPE;</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Measuring containers;</td>
<td>[ ]</td>
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<td>[ ]</td>
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<tr>
<td>Equipment eg. nozzles;</td>
<td>[ ]</td>
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IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.

..........................

..........................

GENERAL COMMENTS.

..........................

..........................

1.1.6 Is there a means of regulating the direction of water from the tank?

YES [ ]
NO [ ]

1.1.7 Is there a means of controlling the pressure of the water?

YES [ ]
NO [ ]

1.1.8 How easy is the tap to operate?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.

..........................

..........................

GENERAL COMMENTS.

..........................

..........................
1.1.9 How easy is the water tank to fill?

<table>
<thead>
<tr>
<th>Rating</th>
</tr>
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<tbody>
<tr>
<td>Very Easy [ ]</td>
</tr>
<tr>
<td>Easy [ ]</td>
</tr>
<tr>
<td>Adequate [ ]</td>
</tr>
<tr>
<td>Difficult [ ]</td>
</tr>
<tr>
<td>Very Difficult [ ]</td>
</tr>
</tbody>
</table>

If rated Difficult or Very Difficult, please give details.

General Comments.


Overall comments about the water supply.

Prompts - capacity
- ease of cleansing
- regulation of direction
- pressure
- operation of tap
- filling water tank.


1.2 Induction system.

The following aspects should be considered in relation to the induction system:

i. It is not desirable to have the chemical containers directly beneath the booms.
ii. It should be easy to attach any probes to the chemical containers.
iii. It should be easy to mount the containers into their position on the sprayer.
1.2.1 How well are the chemical containers located in relation to the booms?

- VERY WELL [ ]
- WELL [ ]
- ADEQUATE [ ]
- POOR [ ]
- VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS

1.2.2 How many chemical containers are used?

1.2.3 How are the chemicals carried on the sprayer?

- a - MANUFACTURERS CONTAINER [ ]
- b - SEPARATE CONTAINER [ ]
- c - OTHER [ ]

If a - Please describe the type of connection which is used to remove the chemical from the manufacturers container and the process which the operator must carry out to attach and detach the system.

Proceed to question 1.2.5

If b or c - Please describe the method which is used to transfer the chemical from the manufacturers containers into the sprayer containers. (If a probe is used see section 1.3)
1.2.4 Are the separate containers filled with chemical on or off the sprayer?

ON [ ]
OFF [ ]

1.2.5 If filled on the sprayer, what is the height of the container opening from the ground? .................. cm

1.2.6 Is the container mounting position easily accessible?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS...

1.2.7 Is the means of mounting and securing the containers easy to use?

YES [ ]
NO [ ]

IF NO, PLEASE GIVE DETAILS...

(b) Is the operator risking injury from performing this task?

YES [ ]
NO [ ]

IF YES, PLEASE GIVE DETAILS...

1.2.8 Please give a general description of the top of the container.

Prompts
- positive stop
- type of lid
- ease of gripping
1.2.9 Rate the ease with which the top of the container can be removed.

VERY EASY [ ]  
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS

GENERAL COMMENTS

1.2.10 Measure the width of the aperture.

1.2.11 What is the capacity of the containers?

1.2.12 Will the container allow for the use of soluble packages?

YES [ ]
NO [ ]

1.2.13 Is a flushing facility available for the pesticide containers?

YES [ ]
NO [ ]

1.2.14 Is the container flushing automatic?

YES [ ]
NO [ ]

IF NO, PLEASE DESCRIBE

Instructions should be present for the safe use of the injection system. It is desirable for these to be in the form of either a warning or in the form of an instruction. They must be;

i. positioned in close proximity to the subject of the instruction;
ii. appropriate
iii. of a long wearing material

1.2.15 Are instructions present?

YES [ ]
NO [ ]
1.2.16 If yes, what form are they in?

WARNING [ ]
INSTRUCTION [ ]
OTHER [ ]

IF OTHER, PLEASE SPECIFY

1.2.17 How are the instructions presented?

DECAL [ ]
MOULDED [ ]
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS

1.2.18 How well are they placed in relation to the task?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS

GENERAL COMMENTS
1.2.19 How well do the instructions impart the relevant information?

- VERY WELL [ ]
- WELL [ ]
- ADEQUATE [ ]
- POOR [ ]
- VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS

GENERAL COMMENTS

OVERALL GENERAL COMMENTS FOR THE INJECTION SYSTEM

Prompts: - location of the system on the sprayer
- access to the containers
- height of the containers
- opening of the containers
- attachment of any connections
- container flushing facilities
- instructions warnings

1.3 PROBE METHOD.

The desirable features to be considered in connection with the probe are;

i. the provision of an anti-drip valve;
ii. the switch which operates the control valve having a fail-safe facility in
   the form of a "dead man's handle";
iii. the provision of cleaning facilities, to allow cleaning of the probe prior
    to storage;
iv. a parking facility, to store the probe away from other equipment;
v. appropriate instructions.

1.3.1 Does the probe have an anti-drip valve?

- YES [ ]
- NO [ ]
1.3.2 Is a "dead man's handle" present on the probe?

YES [ ]
NO [ ]

1.3.3 If no, please describe the controls for the probe.

The control valve for the probe must:

i. be located so that no part of the user is at risk of contamination whilst operating it;
ii. be easily (eg in poor light), and permanently identifiable as to the functions of the control (ie which position is on and which position is off);
iii. conform to recognised conventions;
iv. be easily operable, thus avoiding undue exertion by the operator.

1.3.4 When using the control valve, is the user exposed to any potential hazards from other pieces of equipment?

YES [ ]
NO [ ]

IF YES, PLEASE GIVE DETAILS.

1.3.5 Are the on/off positions of the control valve easily identifiable?

YES [ ]
NO [ ]

1.3.6 Are instructions marked on the handles for the functional use of the control valve?

YES [ ]
NO [ ]

1.3.7 If yes, how are they presented?

DECAL [ ]
MOULDED [ ]
OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS.
1.3.8 Is the information well presented?

YES [ ]

NO [ ]

IF NO, PLEASE GIVE DETAILS...

.................................................................

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1.3.9 Does the operation of the control valve conform to recognised conventions?

YES [ ]

NO [ ]

IF NO, PLEASE GIVE DETAILS...

.................................................................

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1.3.10 Rate the ease of use of the control valve with one hand.

VERY EASY [ ]

EASY [ ]

ADEQUATE [ ]

DIFFICULT [ ]

VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS...

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GENERAL COMMENTS...

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.................................................................

1.3.11 Are effective cleaning facilities for the probe present?

YES [ ]

NO [ ]

1.3.12 If yes, how easy are they to use?

VERY EASY [ ]

EASY [ ]

ADEQUATE [ ]

DIFFICULT [ ]

VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS...

.................................................................

.................................................................
1.3.13 Is a pesticide metering device present on the probe?

YES [ ]

NO [ ]

1.3.14 Are effective storage facilities available for the probe?

YES [ ]

NO [ ]

Instructions should be present for the safe use of the probe. It is desirable for these to be in the form of either a warning or in the form of an instruction. They must be:

i. positioned in close proximity to the subject of the instruction;
ii. relevant to the task;
iii. of a long wearing material.

1.3.15 Are instructions present?

YES [ ]

If no, please proceed to the next section - NO [ ]

1.3.16 If yes, what forms are they in?

WARNING [ ]

INSTRUCTION [ ]

OTHER [ ]

IF OTHER PLEASE GIVE DETAILS

1.3.17 How are the instructions presented?

DECAL [ ]

MOULDED [ ]

OTHER [ ]

IF OTHER PLEASE GIVE DETAILS

1.3.18 Are the instructions placed appropriately in relation to the task?

YES [ ]

NO [ ]

IF NO, PLEASE GIVE DETAILS
1.3.19 How well do the instructions impart the relevant information?

- VERY WELL [ ]
- WELL [ ]
- ADEQUATE [ ]
- POOR [ ]
- VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS...

GENERAL COMMENTS...

GENERAL CONCLUSIONS FOR THE PROBE.

Prompts:
- anti-drip valve
- the control valve
- cleaning facilities
- storage facilities
- instructions/warnings.

1.4 CLEANSING OF THE SPRAYER PIPES AND NOZZLES

After finishing spraying it is important that the system including all pipes, nozzles etc. are flushed out with clean water so no pesticide residues remain in the sprayer when not in use.

1.4.1 Is there any pesticide concentrate residues left in the system?
- YES [ ]
- NO [ ]

1.4.2 Is there a facility to spray clean water only through the system?
- YES [ ]
- NO [ ]
1.4.3 How easy is this process to operate?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS...........................

........................................................................................................................................

........................................................................................................................................

1.4.4 How much water is flushed through the system?..............................litres.

1.4.5 Is there a facility to anticipate the end point of the spraying and therefore switch off the pesticide pumps so as the end of the field is reached any chemical residue is flushed out?

YES [ ]
NO [ ]

1.4.6 If Yes, how easy is this system to use?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS......................

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GENERAL CONCLUSION ABOUT THE CLEANSING SYSTEM.................................

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........................................................................................................................................

2 SPRAYER CONTROLS.

Sprayer controls come in two main varieties, depending upon the type of sprayer;

a. Remote controls, - these are operated within the confines of the cab;
b. Manual controls, - these are operated through the rear window of the cab.

In some instances, it is necessary to set the controls outside first, and then operate an overall on/off switch within the cab.

In terms of safety and efficiency, the in cab (remote) controls are most desirable and the manual controls which require operating out of the window, least desirable.
When the controls are operated through the rear window, there is an increased potential for contamination, due to spray drift entering the open window, or contamination from the controls passing onto the operator's hand.

The controls must be operable by all users from a 5th percentile female to a 95th percentile male, if the controls are situated outside then a 5% allowance for PPE shall be made.

The sprayer controls generally consist of:

i. an emergency out-put kill switch;
ii. overall on/off switch, for all of the spray controls;
iii. individual controls for each segment of the boom;
iv. a control for raising and lowering the boom;
v. pressure control switch, the pressure may adjust automatically to compensate for the switching on/off of boom segments, however often a manual adjustment is often present as well.

All of the controls must:

i. be easily accessible, especially the emergency kill switch, which must be accessible from the ground or from the cab;
ii. be easily identifiable, each control's function must be clearly represented;
iii. be easy to use;
iv. conform to recognised conventions in terms of movement;

2.1 Is there an emergency out-put kill facility present?

YES [ ]

If no, please proceed to question 2.5 - NO [ ]

IF YES, PLEASE GIVE DETAILS...........................................................
................................................................................................................
................................................................................................................

2.2 If yes, where is it situated?

IN-CAB [ ]

ON SPRAYER [ ]
2.3 How easy is the emergency kill facility to use?

   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

   IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS........................................

   ........................................................................................................................................

   GENERAL COMMENTS...........................................................................................................

   ........................................................................................................................................

   2.4 Does the emergency kill facility conform to recognised conventions?

   YES [ ]
   NO [ ]

   IF NO, PLEASE GIVE DETAILS..............................................................................................

   ........................................................................................................................................

   2.5 Is there an overall on/off switch present?

   YES [ ]

   If no, please proceed to question 2.9 - NO [ ]

   2.6 If yes, where is it situated?

   IN-CAB [ ]
   ON SPRAYER [ ]

   2.7 How easy is the overall on/off switch to use?

   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

   IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS........................................

   ........................................................................................................................................

   GENERAL COMMENTS...........................................................................................................

   ........................................................................................................................................
2.8 Does the overall on/off switch conform to recognised conventions?
   YES [ ]
   NO [ ]

IF NO, PLEASE GIVE DETAILS.................................................................
.................................................................................................
.................................................................................................
.................................................................................................

2.9 Are separate boom segment controls present?
   YES [ ]
   If no, please proceed to question 2.13 - NO [ ]

2.10 If yes, then where are they situated?
   IN-CAB [ ]
   ON SPRAYER [ ]

2.11 How easy are the boom segment controls to use?
   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.............
.................................................................................................
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GENERAL COMMENTS.............................................................................
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2.12 Do the boom segment controls conform to recognised conventions?
   YES [ ]
   NO [ ]

IF NO, PLEASE GIVE DETAILS.................................................................
.................................................................................................
.................................................................................................

2.13 Are there separate controls for raising/lowering the booms?
   YES [ ]
   If no - please proceed to question 2.17 - NO [ ]

2.14 If yes, where are they situated?
   IN-CAB [ ]
   ON SPRAYER [ ]
2.15 How easy are the boom raising/lowering controls to use?

- VERY EASY [ ]
- EASY [ ]
- ADEQUATE [ ]
- DIFFICULT [ ]
- VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS...........................................

......................................................................................................................................................................

GENERAL COMMENTS.................................................................................................................................

......................................................................................................................................................................

2.16 Do the boom raising/lowering controls conform to recognised conventions?

- YES [ ]
- NO [ ]

IF NO, PLEASE GIVE DETAILS...................................................................................................................

......................................................................................................................................................................

2.17 Is the pressure control automatic?

- YES [ ]
- NO [ ]

2.18 Is a pressure control switch present?

- YES [ ]

If no - please proceed to question 2.22 - NO [ ]

2.19 If yes, where is it situated?

- IN-CAB [ ]
- ON SPRAYER [ ]

2.20 How easy is the pressure control to use?

- VERY EASY [ ]
- EASY [ ]
- ADEQUATE [ ]
- DIFFICULT [ ]
- VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS...........................................

......................................................................................................................................................................

......................................................................................................................................................................
2.21 Does the pressure control switch conform to recognised conventions?
   YES [ ]
   NO [ ]

IF NO, PLEASE GIVE DETAILS.

2.22 Is the setting of the dosage rate remote or manual?
   REMOTE [ ]
   MANUAL [ ]

2.23 Where is the control situated?
   IN-CAB [ ]
   ON SPRAYER [ ]

2.24 How easy is the dosage control to use?
   VERY EASY [ ]
   EASY [ ]
   ADEQUATE [ ]
   DIFFICULT [ ]
   VERY DIFFICULT [ ]

IF RATED DIFFICULT OR VERY DIFFICULT, PLEASE GIVE DETAILS.

2.25 Once set, can the dosage rate be increased/decreased from the cab for spot treatment?
   YES [ ]
   NO [ ]

2.26 Does the dosage control conform to recognised conventions?
   YES [ ]
   NO [ ]
2.24 Are the functions of the different controls well represented?

YES [ ]

NO [ ]

IF NO, PLEASE GIVE DETAILS...

2.23 Are any further controls present?

YES [ ]

NO [ ]

IF YES, PLEASE GIVE DETAILS...

GENERAL CONCLUSIONS ABOUT THE SPRAYER CONTROLS.

Prompts - presence or absence of the controls
- placement of the controls
- ease of use of the controls
- conformity to recognised conventions
- representation of the controls functions.

5.2 THE PUMPS.

The pumps should be;

i. positively located on the spray unit to prevent movement and resultant damage;

ii. accessible for maintenance and/or cleaning.

5.2.1 How many pumps are there?

Chemical Concentrate [ ]

Diluted Chemical [ ]

Water [ ]
5.2.2 Are all the pumps positively located on the unit?

YES [ ]
NO [ ]

IF NO, PLEASE DESCRIBE THE METHOD OF ATTACHMENT...........................................

..............................................................................................................................

..............................................................................................................................

5.2.2 How accessible are the pumps for maintenance and/or cleaning?

VERY ACCESSIBLE [ ]
ACCESSIBLE [ ]
ADEQUATE [ ]
INACCESSIBLE [ ]
VERY INACCESSIBLE [ ]

IF RATED INACCESSIBLE OR VERY INACCESSIBLE, PLEASE GIVE DETAILS............

..............................................................................................................................

..............................................................................................................................

GENERAL COMMENTS.................................................................................................

..............................................................................................................................

..............................................................................................................................

5.2.3 Are the pumps calibrated remotely or manually?

REMOTELY [ ]
MANUALLY [ ]

5.2.4 How easy is it to calibrate the pumps?

VERY EASY [ ]
EASY [ ]
ADEQUATE [ ]
DIFFICULT [ ]
VERY DIFFICULT [ ]
Instructions should be present for the safe and efficient use of the pumps. It is desirable for these to be in the form of either a warning or in the form of an instruction. They must be:
   i. positioned in close proximity to the subject of the instruction;
   ii. appropriate;
   iii. of a long wearing material.

5.2.5 Are instructions present?  
   YES [ ]  
   If no, please proceed to conclusions for section - NO [ ]

5.2.6 If yes, what forms are they in?  
   WARNING [ ]  
   INSTRUCTION [ ]  
   OTHER [ ]

IF OTHER PLEASE SPECIFY

5.2.7 How are the instructions presented?  
   DECAL [ ]  
   MOULDED [ ]  
   OTHER [ ]

IF OTHER, PLEASE GIVE DETAILS

5.2.8 How well are they placed in relation to the task?  
   VERY WELL [ ]  
   WELL [ ]  
   ADEQUATE [ ]  
   POOR [ ]  
   VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS

GENERAL COMMENTS
5.2.9 How well do the instructions impart the relevant information?

VERY WELL [ ]
WELL [ ]
ADEQUATE [ ]
POOR [ ]
VERY POOR [ ]

IF POOR OR VERY POOR, PLEASE GIVE DETAILS

GENERAL COMMENTS

OVERALL CONCLUSIONS ABOUT THE PUMPS.
Prompt - positively located
- accessibility

8 ACCESS FACILITIES.

On occasions, it is necessary to climb up onto the sprayer unit. This can be for;

a. cleaning purposes;
b. maintenance purposes.

To facilitate easy access, handholds, ladders and platforms may be required.

It should be remembered that the wearing of PPE will limit the level of dexterity and manoeuvrability when climbing aboard the sprayer.

Users ranging in size from a 5th percentile female to a 95th percentile male must be able to gain access onto the sprayer when required.
Appendix 4

Appraisal of closed transfer and injection systems

1.0 Introduction

Closed transfer systems were reviewed separately as only a few are at present commercially available embodying a variety of design concepts which would be difficult to compare with the more standard AFCS commonly available.

Closed systems eliminate the need for the operator to come into contact with neat pesticides and minimise the chances of operator contamination from splashes or accidents. Of the designs studied few completely fulfilled all the requirements of a closed system, but went a lot further than the majority of AFCS.

Definition of a closed transfer system

This definition was used by the California Department of Food and Agriculture (CDFA), when in 1974 they introduced regulations requiring closed systems for very toxic pesticide transfer (cited in Frost and Miller 1988)

A closed transfer system is a means of removing a pesticide from its original container, rinsing the emptied container, and transferring the pesticide and rinse solution through connecting hoses, pipes and couplings that are sufficiently tight to prevent exposure of any person to the pesticide or rinse solution.

The optimum system sought by designers is one that keeps the pesticides and the diluent separate until the point of application, and one that incorporates an automatic volume or output control. That is, a "closed direct injection and metering system".

Requirements of a closed transfer system

1) To minimise operator contamination.

2) To be capable of accommodating a variety of container shapes and sizes, as container standardisation has not yet been implemented fully.

3) All parts of the system which have contact with the pesticide concentrate must be capable of receiving the full range of pesticides without corrosion.
4) The transfer time for the pesticide concentrate should not be significantly longer than that required for manual transfer to prevent the system being misused or not used.

5) The system should have a low capital cost and low running costs eg. for non-reusable components such as disposable probes.

6) A means of rinsing the containers should be available and the rinsings should be used for spraying to eliminate environmental contamination from inconsiderate disposal.

7) Measurement of the pesticide concentrate should be accurate and allow part containers to be used.

8) The system should be reliable and fail safe.

9) Any system needs to be ergonomic and easy to use to minimise the chances of accidents.

A variety of closed transfer systems have been developed, these can be classed generally as:

   a) Container puncturing devices
   b) Sealed suction probes
   c) Gravity operated

Some of these systems include a direct injection system whereby the chemical is injected into the spray lines just before the point of application at a measured rate, others empty the measured quantity of pesticide into the water tank of known volume, as in traditional sprayers.
Investigation plan

Closed transfer/direct injection systems were investigated in two ways:

1) A literature review of the systems available commercially and also those which are under development was undertaken.

2) Visits were arranged to see those systems which are currently commercially available and those which exist as a prototype in this country.

Literature review

Several papers, articles and commercial brochures were reviewed to assess the types of closed systems at present under development and commercially available.

ARFC have developed a system, not yet commercially produced, which is described in an article by Frost (1990). The system is added to a conventional sprayer and consists of a metering pump, pressure and speed sensors, controller, cylinder and piston and mixing chamber. This will be discussed in more detail later as part of the survey.

Ciba-Gelgy in conjunction with MSR in Germany have developed the Agroinject system which is still being tested before commercial marketing.

Up to four different chemicals can be used at one time and are carried in their original containers. Extraction of the chemical is by re-usable probes and the system claims to fit all marketable sizes of container. The chemical is sucked out of the container by a water driven precision dosing pump which then meters the chemical into the mixing chamber which ‘guarantees homogeneous spray fluid’.

A computerised in-cab controller is used to give operator accuracy in calculating doses but these are then set manually using a regulating sleeve on the pump. The in-cab controller allows monitoring of the operating conditions, changes in driver speeds and targeting of partial areas.

The system has a rinse mechanism which is switched on from the cab, just prior to the completion of the spraying leaving the system containing only clean water. The original containers with part contents can be stored or there is a mechanism for rinsing the used containers.
The container rinsing system claims to be simple, avoids all operator contact with the rinsing liquid and discharges the waste.

**Vicon**

A system is also being developed, in Holland, by Vicon but is not yet commercially available. It is capable of using four chemicals, three liquid and one powder/dispersible granule after pre-mixing.

An electrically driven peristaltic pump is connected to two tubes one small and one large. The pump sucks the chemical from its container using a probe and the chemical then travels through this pump to the inlet side of the main axial piston pump. The water is mixed with the chemical here before going to the nozzles. A computer is programmed with the dose rates and the quantity of chemical injected is altered by changing the speed of the electric motor. Altering the output to cope with changes in boom sections, speed etc. is also by electronics which change the main pumps piston length. These two functions can be regulated together to maintain a constant concentration at the nozzle as the effect of changing the operating parameters takes place immediately.

**Agrifutura** have two retrofit systems on the market, the Dose 2000 and the smaller Dose 500. These systems were studied and evaluated as part of the survey.

**Handbury Machine Services** also have two systems available, the CCI 2000 and the ISC 3500, these were evaluated in the survey.

**Wisdom**

This system came onto the market during the project and was not evaluated. The system allows for the use of full containers and part containers using two methods. The contents are sucked out using a venturi valve arrangement connected to the container using dry-break couplings which also allows air into the container. The container is held in a frame inverted and has a rinse mechanism which transmits water through the air pipe. If part containers are required chemical is drawn into a calibrated mixing chamber by a piston pump before going to the spray lines. As an addition a facility for using solid pesticides can be incorporated. The whole system is located on the side of a conventional sprayer.
Packman

The Packman closed transfer system consists of a cabinet in which up to six unopened chemical containers are placed and the lid closed. A handle on the side of the unit is turned which lowers spears into the containers piercing both the top and bottom. As they are pierced rinse water is automatically switched on and the concentrate drains out into the sump. The inside and outside of the containers are thoroughly rinsed and all the contents of the sump are transferred to the sprayer tank via a venturi. The spears are withdrawn and the clean containers removed.

The Packman, by emptying up to six containers at once is quicker than an induction bowl or manual induction, containers do not need to be opened or rinsed separately and this system also renders the packs unsuitable for re-use.

The speed of the process allows wettable powders or water dispersible granules to be completely emptied and thoroughly rinsed without the paper or cardboard containers becoming difficult to handle.

Water soluble packaging

Water soluble packaging could be considered as a form of closed system as the operator does not come into direct contact with the chemical. Water dispersible granules also greatly reduce the risk of operator contamination. These both have one main disadvantage in that they have to be stored carefully away from damp. Some induction bowls may not be able to cope with them and the operator will once again need to climb up onto the sprayer to place them directly into the water tank. A further problem here may be thorough mixing of the diluent and the time taken for it to be thoroughly mixed.

Revision of checklist to survey closed systems

The checklist was studied to assess which sections were still relevant, which sections needed alteration, what new sections were required and which sections were obsolete.

The following sections required no alterations:

3.2 - Used PPE store
3.3 - Spare uncontaminated equipment store
3.4 - Pesticides container store
3.4 - First aid kit
4.1 - Remote booms
4.2 - Manual booms
5.1 - Nozzles
5.4 - Hose clips
6.0 - The cab
7.2 - The contents gauge
7.3 - Baffles
8.1 - Handholds
8.2 - Ladders
8.3 - Platforms
9.0 - Hazard warnings and instructions

The following sections required alterations:

1.1 - Clean water supply
1.3 - Probe
2.0 - Sprayer controls
5.3 - The pump
8.0 - Access facilities

The following sections became obsolete:

1.2 - Low level induction hopper
1.4 - Manual method of induction
7.1 - Drainage of the tank

Two new sections were added:

1.2 - Induction system
1.4 - Cleansing of the pipes and nozzles
The section evaluating the induction system gives emphasis to the location of the chemical containers including height and also the ease and safety of mounting them onto the sprayer. It is not advisable for the system, especially if a retrofit system added to an existing sprayer, to be located beneath the booms.

The number of containers, either manufacturers or those provided and the means of attaching them are assessed. An evaluation of the ease of filling containers and/or the ease of attaching probes or couplings is included.

The provision of instructions for using the induction system, there location and there effectiveness in imparting the information is included.

The checklist also evaluated the cleansing mechanism for the system if provided, it's ease of use and any extra features were studied.

The sections which were altered included the clean water supply which could possibly be a tap from the main tank if the system is an injection system.

Different sprayer controls are required for a closed injection system. The setting of the dosage rate and the controls for changing dosage rates while on the move differ from conventional sprayers. Minor Alterations were therefore needed for this section.

The section on pumps was altered to allow for the different pumps, (water, chemical concentrate, and diluted chemical), and to assess there location and ease of calibration and access.

The introduction to the access facilities section was changed as access is only required for cleaning and maintenance and not for manual induction purposes.

The probe section remained to allow for the evaluation of any probes attached to containers which are used to withdraw chemical directly to the system.
Sample and survey

The following systems were investigated first hand:

- Agrifutura Dose 2000
- Agrifutura Dose 500
- Handbury Machine Services Turbo Electronic
- AFRC prototype

**Agrifutura Dose 2000**

This is a retrofit system which can be fitted to any sprayer. It is capable of handling three chemicals which can be applied independently of each other. The system consists of its own 35L pesticide containers to which the pesticide is added off the sprayer. They are mounted on a rack and provide enough pesticide to avoid running out before the water tank is empty. The pesticide is pumped by a high precision dosing pump and mixed in a chamber before being injected. The dosage level is adjusted automatically according to certain parameters registered by various sensors, including a ground speed sensor wheel to monitor travel speed. The stroke length of the pump's pistons is changed by a stepper motor automatically to alter the amount of chemical injected.

Five doses are programmed into the controller, including one zero dose and these are shown on a display. During operation the dose is altered by switching between these settings, or for spot treatments an increase/decrease button can be used. At the end of a spraying session the system can be switched to water only to leave clean water in the pipes. The display shows the distance from the end of the field that the chemical should be switched off.

The display also has a facility to show when the diluted pesticide has reached the furthest nozzle after this is switched on. Other data which is supplied is area covered, current flow of water and total volume sprayed.
Warning indicators include:

- Pesticide container empty
- Water tank empty
- Hose leak
- Overloading of the pump
- System error

The system ranges in price from approximately £5000 - £8000 depending on the number of pumps.

As this is a retrofit system when it was evaluated using the checklist, only a few of the sections were completed as much depends on the sprayer to which it is fitted.

**Induction**

This system can be described as a direct injection system but not a closed system as the chemical still has to be decanted by the operator into larger containers to keep the machine working in the field for longer periods. A hydraulic pump is available as an optional extra for filling the containers. If part containers are required a measuring cylinder is provided as an optional extra but this has a relatively thin opening in which to pour the chemical into. Probes are then inserted into the container and secured using a crude T-shaped handle. There are two bar handles on the 35L containers which are unsuitable for carrying such a weight. The top for the container is a screw type which can be removed easily and provides adequate pouring space. There is no flushing facility available for the containers, so this must be carried out manually.

**Cleansing of the system**

Up to 35L of water can be flushed through the pump and pipes at the end of the spraying session. This process is very easy to operate and the point at which to start this process is indicated by the in-cab controller.
Controls

The in-cab controller is used to set dosages and this can be done very easily and can be changed on the move. The functions of the controls are well represented and there are several indicator/warning lights present.

Pumps

There are three pumps which are positively located on the system and should be accessible depending on the location of the system on the sprayer. These are easy to calibrate and are done so remotely.

Dose 500

The Dose 500 is a smaller system which can still handle up to three different chemicals but is less sophisticated. The pumps are manually calibrated, so dose rates cannot be changed for spot treatments or changes in speed. As a smaller system this has the advantage of not requiring the operator to decant the chemical into bigger containers - the manufacturers containers are used and connected to the system using probes. It is possible to use the Agrifutura 35L containers if required. They fit onto an adjustable height platform with conical shaped connectors that cater for all sizes of container neck. The price is approximately £3000 for a three pump system.

This system was mounted on a sprayer when evaluated, but the mounting position will vary depending on the different sprayers. The system was well located away from the booms. The height at which the containers have to be mounted depends upon the size of the container and location on the sprayer, but was accessible on the sprayer viewed. The manufacturers containers are mounted on a height adjustable platform. A probe is fitted through a conical shaped piece of plastic which is placed in the container and fits different sized necks. The container is placed on the platform, raised until the the hole in the probe holder meets the connector attached to the pumps. The platform is then fixed in place using a simple bar lever which is difficult to put any pressure onto. Soluble packages can be placed in the large Agrifutura container if needed as in the Dose 2000.

Cleansing of the system

No flushing facility is available for the containers but the system can be cleaned in the same way as the Dose 2000.
Pumps and controls

The pumps are set manually following a scale marked on them and this is easy enough to do but does not allow the settings to be changed while on the move. The pumps are accessible, easy to use and instructions were present, for the calibration and setting of the correct dosages. The instructions were placed well and imparted the relevant information well too.

Handbury Machine Services

CCI2000/Turbo Electronic

This is also a retrofit kit which can handle up to three different chemicals, but is only fitted to sprayers produced by Handbury. Chemical is transferred from the manufacturers container into 90L tanks. The dosage rate is dialled into the in-cab controller, as the sprayer is switched on chemical is drawn out of the tanks by separate pumps driven by electric motors which meter the chemical into a manifold where they are mixed with the water. The diluent is then transferred through a return manifold and through the main pump to the nozzles. A butterfly valve is used to control the amount of diluent being sprayed in relation to speed. Other valves in the system ensure that the main water supply does not become contaminated with chemical and also transfer the diluent back to the return manifold if a boom segment is switched off. The three chemical pumps can be altered separately if spot treatments are required or an 5% increment increase/decrease switch can be used.

The in-cab controller provides much information on speed, application rate, distance travelled and increase/decrease in rate as well as error warnings. This in-cab controller is also capable of providing printouts of information for farmer records.

Induction

The tanks were badly positioned directly underneath the booms, with cramped access space.

Three tanks are provided to decant the chemical into, one which swings down on a pivot and two which are removable and snap into a frame. The swing down tank was very stiff, difficult to access and no handhold was provided to guide it to the low position. All the tanks when mounted were quite high but the two removable tanks could be filled off the sprayer if required. The apertures of these tanks was also on the small size.
A hose is provided from the main tank for washing the operator and also for rinsing the tanks. The rinsings are then placed in a fourth tank labelled can washings. No instructions were present.

**Controls**

The controls are located in the cab and most were easy to use except they did not conform to recognised British conventions i.e. up - On, down - off, and the emergency kill switch was right - on, left - off. The boom segment controls were also small and positioned too close together. The pump was adequately accessible. A warning was present about overhead power lines but this was located away from the boom controls. Drainage of the main tank was poorly accessible and awkward to use but this is of much less importance than conventional AFCS as only water is stored in the tank.

A smaller system, the ISC 3500, which handles two chemicals is also available at approximately £3,500.

**AFRC Engineering**

This system is still at prototype level. The system can handle up to three chemicals, stored in their original containers. Probes are inserted into the containers and chemical is extracted by a double chambered indirect pump. An in-cab controller is used to set dosage rates.

The process begins when water is drawn out of the indirect pump lower chamber by a venturi created by the main pump. The pump piston is drawn down and chemical is sucked out of its container through a one-way valve and into the upper chamber of the pump. The valve causing the venturi is then switched over which pumps the water through a pressure control valve towards the mixing chamber. A speed sensor is located on the wheel of the vehicle and the flow rate of the chemical is controlled by a metering pump which injects water into the lower chamber of the pump. The amount of water entering the pump is directly proportional to the amount of chemical leaving the pump. The piston moves up and the chemical is transferred through another one way valve to the mixing chamber. Here it mixes with the water before going to the boom. This system benefits from the use of this pump as it is easier to indirectly control the chemical by controlling the flow of water than directly, due to the many different physical properties of chemicals.

As a prototype certain aspects of the system are not definitive and several possibilities for the number and size of the water/chemical cylinder could be considered. The size of the chamber
can be matched to the size of the tank to ensure the amount of chemical is not insufficient for a full tanks spraying. Two cylinders could be used to allow one to be used as the other is filled to keep a constant supply. A third option would be that one cylinder is used and refilled at breaks in the spraying such as at the headland. At the end of spraying clean water can be used to flush out the system and the dilute rinsings sprayed on the field. The additional amount of chemical sprayed would be negligible.

**Advantages and disadvantages of closed Induction systems**

The advantages of closed mixing and direct injection systems are as follows (Bahar, 1987, p 349):

a) The sprayer tank contains water only and no longer has to be agitated;

b) All construction elements for the water line before the point of injection no longer need to be pesticide resistant;

c) By adjusting the concentrate flow, the volume of active substance applied per unit area may be held constant despite speed variations;

d) Off-target spray drift can be reduced and spray pattern uniformity optimised by the ability of the machine to apply spray at constant pressure, regardless of variation of travel speed;

e) The great problem of pesticide wastes is solved. Concentrate which is not used may be stored in the manufactory's container and used later. Clean water can be sprayed at the end of the session and a change from one pesticide to another is possible without problems and delay. The spraying at the end reduces the risk to the environment as the chemical is more dilute.

f) The expense of applying pesticides is reduced (ie eliminating the application of unrecommended excessive dosages) by having a proper accurate metering system controlled by electronic pumps.

g) The dosage rate can be adjusted on the move to allow for different levels of infestation, spot treatments and headland spraying.
h) The operator need not handle concentrate pesticides which reduces the risk of splashing although in some systems decanting the concentrate into larger containers is still required.

i) More time is available for spraying as less time is required for calculating quantities, donning and doffing full PPE, decanting chemical and the tank needs only to be filled with water. If a change in chemical is required disconnecting of the container, replacing it and connecting it is all that is needed.

j) Most closed systems can be fitted to existing sprayers.

There are of course disadvantages to the closed mixing and direct injection system, and they are (Bahar, 1987, p 349):

a) Their expense, this may be high initially but the reduction of waste may offset this.

b) Their inability to respond quickly to changes in travel speed.

c) The need for trained operators.

d) The possible detrimental effects of the concentrate upon components.

e) Chemical concentrate is put under pressure in this system and this poses a safety risk. If a pipe bursts concentrate not diluent is released and there is a greater risk to the operator and the environment. The pipes and components which receive concentrate under pressure should be enclosed.

f) There is incompatibility between the chemical concentrate container size and the volume required to keep large sprayers working in the field for long periods. Chemical is therefore decanted into larger containers in some systems overriding one of the main benefits of the system.

Pilot of the checklist

The Checklist for the injection system was piloted on the Agrifutura systems and some minor changes needed to be made to allow for the variety of closed induction systems that may become available. The induction section required no changes but the probe section, which was largely
unchanged from the original checklist, needed alterations as the probe is not likely to be manually operated but inserted into a container after which the process becomes automatic.

Results of the survey

The systems studied do provide the operator with improved safety in terms of less contact but some still cold not be classed as closed. Systems which still require chemical concentrate to be decanted into bigger containers still pose as much a risk as pouring into induction bowls, but are more environment friendly. By only mixing the chemical just prior to spraying there is no waste. Ergonomically these systems have room for improvement with respect to operator safety.

The advantages of closed mixing and direct injection systems are as follows (Bahar, 1987, p 349):

a) the sprayer tank contains water only and no longer has to be agitated;

b) all construction elements for the water line before the point of injection no longer need to be pesticide resistant;

c) by adjusting the concentrate flow, the volume of active substance applied per unit area may be held constant despite speed variations;

d) off-target spray drift can be reduced and spray pattern uniformity optimised by the ability of the machine to apply spray at constant pressure, regardless of variation of travel speed;

e) the great problem of pesticide wastes is solved. Concentrate which is not used may be stored in the manufacturer's container and used later. A change from one pesticide to another is possible without problems and delay, and;

f) the expense of applying pesticides is reduced (ie eliminating the application of unrecommended excessive dosages) by having a proper metering system;

g) the operator need not handle concentrate pesticides.

There are of course disadvantages to the closed mixing and direct injection system, and they are (Bahar, 1987, p 349):
a) their expense, 

b) their inability to respond quickly to changes in travel speed, 

c) the need for trained operators 

d) the possible detrimental effects of the concentrate upon components. 

D. L. Reichard and T. L. Ladd (1983) also looked at the need for, and the development of, direct injection systems. They managed to develop such a system, however they concluded that a “system that is simpler to use would be more desirable”. 

The metering system does not have direct relevance for the purpose of this project, however the direct injection system does. The system basically works by injecting the pesticide (which is drawn directly from the manufacturers container) into the diluent immediately before it is applied through the nozzles. Reichard and Ladd (1983) in their closed mixing and direct injection system, also included a container washer as a further attempt to reduce potential operator contamination. 

It has been the dream of most agricultural research engineers to develop an optimal pesticide spraying system in terms of safety. This system would ideally exclude the involvement of the operator to a large degree. Traditionally, it has been necessary for the operator to manually induct neat pesticide by pouring it directly into the sprayer tank. This potentially high risk situation, with the potential for spillage, slipping/falling splashing and so forth, may result in the potential for contamination through dermal contact, inhalation or possibly ingestion. S. J. Bahar (1987), discussed the need for a closed direct injection systems and their relative advantages and disadvantages.
Appendix 5

Fundamental design faults

With many of the crop sprayers evaluated several fundamental design faults were identified. It was felt useful to list these in order, to assist designers and manufacturers of future crop sprayers in improving their designs.

1 Hoppers
   a) Some sprayers had the facility to store the hopper when not in use. The raising and lowering mechanism employed was often very difficult and sometimes unsafe to use.
   b) Filling heights for induction hoppers were found to vary considerably and were often too high or too low for safe pouring of pesticide liquid.

2 Access to and from the cab and other parts of the sprayer
   a) In many instances folded booms were found to restrict operators' access to cabs, to sprayer tanks and certain controls.
   b) Many ladders and platforms had their first step much too high above the ground for safe and easy access.
   c) In general there were an insufficient number of grab rails present.
   d) Many grab handles were poorly designed in terms of their functional position, size and shape.
   e) On several models, when the booms were in the closed position, there was a temptation to use parts as a handrail.

3 Controls
   a) In many instances critical controls on the sprayer and in the cab lacked suitable mechanisms to prevent inadvertent or inappropriate use.
b) Controls in general were designed from the point of view of technical function with little or no consideration given to ease of use, their functional shape or their location on the sprayer.

d) Many valve controls had poor directional indicators marked on them. Furthermore, they generally lacked any 'positive stops', providing no effective position feedback for the operator.

d) Many operational controls were either ambiguously labelled or unlabelled.

4 Instructions and warnings

Instructions and warnings on the sprayer were generally poor both in terms of their message and comprehension.

5 Hoses

In some instances hoses were routed through the cab.

6 Equipment and PPE storage on the sprayer

a) Comparatively few AFCS's evaluated were fitted with a P.P.E. store as standard and almost none were fitted with separately designated 'clean' and 'dirty' clothing stores.

b) Many equipment stores had a lip at their edge - making cleaning difficult. Also, containers constructed from fibreglass, in many instances, had a raw edge. It is suggested that this may lead to problems of leaching of pesticide residue into the fibre mat, with the resultant risk of scratching (and possible contamination) of human skin etc.

7 Drainage

Tank drainage facilities were almost universally poor, requiring the operator to crawl underneath the sprayer to remove plugs or connect up pipe work. This is both hazardous in terms of the potential for contamination of the user and the environment. There should of course, be no need to use the draining facility, if calibration has been done accurately.
8 Rinsing and washing down

Very few sprayers had any 'directional' facility for their clean water supplies, where present.

9 Lifting

a) Several of the clean water supply systems, where fitted had to be lifted into position after filling, with the possibility of imposing the risk of biomechanical stress upon the user.

b) Lifting of induction bowls into their storage position, specifically if not, well, cantilever balanced, poses the risk of biomechanical stress.

c) In instances which necessitate the lifting of pesticide containers into the filling position (manual induction methods) there was an obvious risk of postural strain.

10 Exertion

a) Releasing mechanisms for induction bowls were often difficult to access and sometimes arid unsafe to use.

b) Folding and unfolding of manually operated booms poses the risk of biomechanical stress.

11 Guards

a) Several models of small mounted sprayers with manually operated booms had unguarded winch gears giving a potential for pinching and entrapment.

b) With several MB trac's, no toe boards or guard rails were provided for the operator when climbing over mudguards to gain access to the tank.

c) In most cases access platforms were unguarded, this was particularly true with mounted sprayers.
1.2 Undesirable safety related features

a) The position of clean water supplies, PPE stores, operational controls and induction bowls were all too often placed under booms, with the resultant risk of contamination due to drips falling from nozzles.

b) Comparatively few sprayers fitted with a P.P.E. store, and none fitted with a separately designated ‘clean’ and, separate, ‘dirty’ clothing store.

c) Only two of the AFCS’s evaluated had a first aid kit, and even these were provided as optional extras.