THE ADOPTION OF SILO SEALING BY WESTERN AUSTRALIAN FARMERS

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ABSTRACT

The paper describes the circumstances which led to an interest in sealed storage for the control of stored grains insect pests in Western Australia and the way in which the technique was introduced to farmers. Four groups are identified as being associated with the development of on-farm sealed stores; sealant manufactureres, silo manufacturers, contractors and farmers. The problems faced by each group in achieving a satisfactory product are outlined, together with some of the solutions including the acceptance of a static pressure test to measure the efficiency of sealing. The way this development has been adopted by Western Australian farmers is reviewed, together with the present situation and prospects for future development.

The Development of Silo Sealing in Western Australia

In the wheatbelt areas of Western Australia temperatures in the upper thirties ^{o}C are quite usual in the three months following harvest (January-March), creating favourable conditions for the development of stored grain insect pest infestations in farm silos.

In recent years the prinicpal theme in extension programmes for insect control has been to promote a high level of farm hygiene and the concept of a 'clean pipeline'. This involves the elimination, as far as possible, of storage pests entering bulk receival points from farms. Farmers are urged to pay special attention to cleaning and disinfection of all grain handling equipment (headers, augers, field bins, trucks) prior to harvest. Whilst this policy has been largely successful, the problem still remained of keeping grain stored on-farm, free of insect pests.

Only two options are presently available to Western Australian farmers for the on-farm control of insect pests of stored grains.

(a) Treatment of the grain with Malathion as a protectant. No other insecticide is registered for this purpose in Western Australia.

(b) Fumigation - usually using phosphine gas generating tablets (Phostoxin, Gastoxin, Detecia gas-XB).

Increasing resistance to Malathion by some insects, notably *Rhyzopertha dominica* and *Tribolium castaneum*, is becoming a problem. However, Malathion is currently the only protectant registered under the Western Australian Health Act (pesticide regulations) for use on grain stored on the farm. This restriction has been imposed in an effort to delay for as long as possible the

development of resistance to other pesticides that may be used elsewhere for the control of stored grain insect pests. Fenitrothion and other insecticides used elsewhere are reserved for use only by the Grain Handling Authorities in Western Australia at the request of the Grain Weevil Liaison Committee. This body includes representatives from the Western Australian Department of Agriculture, Co-operative Bulk Handling, Agriculture Protection Board, Australian Wheat Board, Primary Industry Association (formerly the Farmers Union) and the Pastoralists and Graziers Association. This policy appears to have been justified, although Co-operative Bulk Handling (CBH) are now finding some instances of resistance to Fenitrothion, especially in *Rhyzopertha dominica* and *Oryzaephilus surinamensis*. As farmers are permitted to treat empty grain storage areas and grain handling machinery with fenitrothion, this resistance may have developed initially on-farm, however CBH do not rule out the possibility of this resistance becoming established in bulk handling operations off farms. Nevertheless since these restrictions on the use of alternative insecticides are likely to continue in Western Australia, farmers are left with fumigation as the only effective protection against insect infestations in stored grains. The problem facing farmers is that the average farm silo is not gastight and is completely incapable of maintaining fumigants at an adequate concentration for a sufficiently long time for total insect kill. The problem would be solved if the silo were made gastight.

A leading role in research and development of sealed and controlled atmosphere storage was undertaken by Dr Banks and his team at CSIRO. The results obtained from their work led to studies in the application of their techniques in Western Australia.

In the period 1972-77 the Western Australian Department of Agriculture conducted trials with grain held in underground stores. In one trial at Salmon Gums, 120 tonnes of grain were stored in a plastic lined pit. Grain temperatures and moisture were maintained at a satisfactory level for three years and the low oxygen concentrations obtained early in the trial were maintained. Further trials were also held at the Merredin Research Station. Whilst the trials showed that grain could be stored in a sealed condition, it was considered this method was not practical for farmers because of the difficulty in handling grain into and out of underground stores. CBH also conducted trials. Some of their bulk storage cells were sealed in 1979 which led to the development of materials suitable for sealing both bulk and on-farm silos.

In 1977 the responsibility for enforcing the control of stored grain insect pests on farms was transferred from the Western Australian Department of Agriculture to the Agriculture Protection Board (APB), although the Department continued with research and resistance testing.

The APB has over 100 officers in the agricultural areas of Western Australia. Staff visit all landholders on a regular basis; carry out inspections for declared plants and animals; advise on their control and, if necessary, enforce and carry out control measures. This activity permits a close monitoring of conditions on farms. However, this responsibility for storage insect pests was quite new to the APB, whose only previous involvement with insects of any species had been in the control of small plague grasshoppers and Australian plague locusts. An intensive training course for APB officers was undertaken and new control strategies were evaluated.

Under the Agriculture and Related Resources Protection Act, the APB 'declared' eleven species of stored grain pests which makes the landholder, or person leasing the land on which these insects are found, legally responsible for carrying out control operations.

The species declared were:

Lesser grain borer	(*Rhyzopertha dominica*)
Rust-red flour beetle	(*Tribolium castaneum*)
Confused flour beetle	(*Tribolium confusum*)
Sawtooth grain beetle	(*Oryzaephilus surinamensis*)
Flat grain beetle	(*Cryptolestes* spp.)
Rice weevil	(*Sitophilus oryzae*)
Granary weevil	(*Sitophilus granarius*)
Indian meal moth	(*Plodia interpunctella*)
Angoumois grain moth	(*Sitotroga cerealella*)
Warehouse moth	(*Ephestia* spp.)
Warehouse beetle	(*Trogoderma variabile*)

In addition to farm visits for inspections and to monitor implementation of control programmes, a series of promotional ventures was carried out by the APB. One was a competition to find the farmer who had the most effective level of farm hygiene. Another was for a silo design including such features as: ease of emptying, cleaning and fumigation; efficiency of fumigant dispersal; airtightness; elimination of grain residues collection areas. Prizes were donated for these competitions by various organisations with an interest in reducing levels of insect infestation and in co-ordinating control strategies over the entire grain industry. The results of the initial sealing trials carried out by CBH were combined with improved farm silo designs originating in part from the APB competition. In consequence, the on-farm sealed silo was launched.

Promotion of Farm Silo Sealing

In 1981 CBH invited all silo manufacturers to submit a silo or silos for an exhibition or non-competitive demonstration at a site near Perth. The silos were sealed using Wastolan, Envelon and Formrok, products previously tried on CBH bulk storages. Because it was felt many farmers were unable to visit the display APB organised a silo sealing 'roadshow' to visit 24 centres in the northern and central wheatbelt and hold field days on selected farms.

This roadshow consisted of 3 demonstration silos mounted on trucks or trailers; (a) a normal 300 bushel (6 tonnes) silo sealed with Formrok; (b) a silo sealed during manufacture with Envelon, constructed so it could be opened and the internal sealing inspected; (Fig 1)(c) a small model silo sealed externally with Wastolan.

The format of this roadshow included:

I. An introductory talk by the APB officer on the reasons for sealing silos, emphasising the need for total insect control to reduce grain damage on farms and to protect export markets, problems of Malathion resistance, reduction in insect control costs through fumigation in sealed silos.

II. A demonstration of the inability of a conventional unsealed farm silo to retain fumigant by placing a coloured smoke bomb in the silo. (Fig 2)

III. Presentation of a film illustrating the practical methods of sealing silos.

IV. Practical demonstrations of the application of silo sealing materials. Agents of the companies supplying the products were invited to demonstrate them, but it was generally carried out by an APB officer. (Figs 3 & 4)

V. To conclude there was a quiz on aspects of silo sealing. At the end of the tour the respondent with the most correct answers received a prize of sufficient sealant for a 56 tonne (2,000 bushel) silo.

The roadshow was supported by wide publicity and proved so popular the tour was extended to cover the entire agricultural area, including over 40 venues, between July and November 1981. The demonstrations were attended by more than 3,000 people.

In addition to on-farm demonstrations, silo sealing was promoted at country shows and machinery field days throughout the grain growing areas. The APB also arranged for the sealing of one silo on selected Department of Agriculture research stations. Sealing costs were met by the Department of

Agriculture whilst the APB covered the contractors travel and accommodation costs. The purpose of this exercise was three-fold:

(a) To give all APB officers the opportunity to see and familiarise themselves with the complete sealing of a farm silo.

(b) To give interested farmers the opportunity to see the operation being carried out.

(c) It was hoped that research stations having a sealed silo would encourage more farmers to seal their own silos.

The promotion of silo sealing by APB and CBH generated a great deal of interest in the farming community, which in turn stimulated activity amongst:

I. Sealant manufacturers;

II. Silo manufacturers;

III. Contractors offering an on-farm sealing service;

IV. Application of sealants by farmers.

Sealant Manufacturers

The development of sealants suitable for use on on-farm silos resulted largely from work on CBH bulk stores. From these it was evident sealing materials had to meet minimum specifications:

(a) Flexible, to accommodate at least 200% elongation without breaking and to retain this flexibility for a number of years;

(b) Adhesion to both metal and concrete surfaces;

(c) Non-toxic when cured and not to contaminate foodstuffs;

(d) Not to break down in sunlight if used on the outside of a silo and to resist abrasion from grain if used internally;

(e) Not react with, or break down in the presence of, any fumigants or insecticides used in the control of stored grain insect pests;

(f) May be applied either as a spray or by brushing without any special skills or equipment.

Initially three products met these requirements:

ENVELON - produced by Dominion Plastic Industries of Melbourne and marketed in Western Australia by Liquid Membrane Supplies of 7 Malcolm Road, Maddington 6109.

FORMROK - produced by Hitchins Australia and distributed in Western Australia by Unitex Coatings of 20 Rio Street, Bayswater 6053.

WASTOLAN - produced by VAT in Hamburg, West Germany and imported and distributed by Woodkon Pty Ltd. of 140 Great Northern Highway, Middle Swan 6056.

During the last year a further two products have been developed and marketed in Western Australia. These are:

ACRONYL and ACROLYNE - produced by Rochelle Chemicals, PO Box 42, Wembley 6014.

SILOFLEX - produced by Crommelin Chemicals, 72 Division Street, Welshpool 6106.

Of these, Wastolan and Siloflex are basically similar products being water based modified acrylic emulsion formulations. Acronyl is also an acrylic but is slightly different in that it is solvent based but water soluble. Acrolyne is an acrylic-styrene membrane that is also used to provide an overall reflective white coat when using Acronyl to seal the joints. Envelon is an organic solvent based polymeric vinyl and Formrok is a two part urethane-elastamer which requires mixing in correct proportions immediately prior to using.

All are excellent for sealing on-farm silos and the decision on which material to use is a matter of price, convenience and personal choice. In general the costs of all products would be around A$1.00 per linear metre of joint covered.

The advantages of the acrylic based materials is that they are completely safe to use, there are no toxic fumes or fire risks when applying them. Daily cleaning of equipment is easy as water only is required (a thorough periodic cleaning with solvents is necessary however). A

disadvantage is that in cold, damp or high humidity conditions these products can take some hours or even days to cure. A 2mm thickness of these materials will cure in less than 45 minutes when temperatures are not less than 20°C at 30% relative humidity. At higher temperatures drying time is reduced to a few minutes.

Envelon, which is organic solvent based, dries within two minutes of application under all conditions. A disadvantage is that when used in a limited space it produces toxic and inflammable fumes. An air-wash mask must be used when applying Envelon in a confined space. In general Envelon tends to be used more by the manufacturers producing sealed silos because of its quick drying properties making it suited to production line techniques. Acronyl, Wastolan and Siloflex are the popular choice of contractors because of the ease of application and enhanced safety factor. However this is not an inflexible rule since some large silo manufacturers use acrylics and some contractors use Envelon, especially in the winter months.

Formrok is a product with maximum adhesion and elasticity and forms an excellent seal when used on farm silos. However, as this is a specialised two part product usually needing to be applied by trained operators, it has not as yet obtained an appreciable share of the Western Australian farm silo market.

Silo Manufacturers

In Western Australia over 95% of the silo market is supplied by factory produced silos, ranging in capacity from 8 to 60 tonnes (300 to 2,250 bushels). Few small prefabricated silos (less than 64 tonnes capacity) are sold and some specialist farmers, such as large scale pig producers, use much larger silos up to 1,200 tonnes (45,000 bushel) capacity.

The APB competition in 1979 for a silo that made pest control easier was won by Walker Engineering. Walkers further developed their original design and in 1980 became the first manufacturer in Western Australia to offer a range of sealed silos. However, less than 3% of their production for 1980 was of sealed silos. Following the CBH exhibition at Midland and during the APB roadshow, other manufacturers changed their production designs and added sealed silos to their range, including Moylan's of Kellerberrin, Becker's of Wyalkatchem, Stearne's of Esperance and Bird's of Popanyinning. It is interesting that these manufacturers were in the rural areas of Western Australia. It was not until 1982 that a metropolitan manufacturer offered a sealed silo.

One of the early problems of promoting sealed silos was the lack of support from some agents and distributors because they had considerable stocks of unsealed silos on hand. Many changes had to be made to silos to obtain a satisfactory level of seal; the design of inlets and outlets to enable

silos to be easily resealed on closure; modifications to the construction of the roof; the joint areas between the roof and wall and the wall and the bottom cone.

The sealing of vertical and horizontal joints is usually carried out by spraying the sealant directly over the joint and for approximately 30mm on each side. A primer may first be applied to provide good adhesion of the sealant, particularly newly galvanised surfaces to which sealants do not usually adhere. Where there maybe movement or there are gaps between the metal sheets, tape or filler must first be applied to act as a filler and backing for the sealant and allow movement or stress to be spread over a greater area.

Not all manufacturers seal their joints in this way. Birds of Popanyinning use a silicone sealant (Selleys 780), a thin band of silicone is run between the metal sheets of the wall prior to riveting them together. Rivetting compresses and spreads the sealant between the joints to give an effective seal.

Many manufacturers have changed the design of the roof from a number of individual panels to a one piece welded unit, (in larger capacity silos, this type of roof may require additional strengthening), which avoids the need for taping or filling and sealing. Boyd Metal Industries of Welshpool produce a model with a glassfibre roof which entirely eliminates the sealing of roof joints.

One major problem is that of making all inlets and outlets easily resealable. In the early days of sealing it was suggested that these could be covered with tape, painted over with the sealant to seal the silo and this would be cut away to open it again. This was not a practical option. Re-opening was extremely difficult due to the strength and adhesion of the sealant which also built up around the inlets and outlets after several applications. In many cases farmers simply did not get around to re-taping and re-sealing these areas. The problem with sealing the roof entry points and hatch covers was solved by the use of spun metal discs pulled down onto rubber faced collars by means of springs or levers (Fig 5). Alternatively one manufacturer fits his sealing lids into the inside of the silo and these are pulled up tight to the opening by means of a clamp or screw.

It now remains a problem to find a suitable rubber material to form the seal round the hatches which will not deteriorate in the high temperatures of Western Australia summer. Attempts to use polyurethane screw down spray tank lids were not entirely successful as these tended to warp and become brittle after exposure.

The designs of silo discharge outlets show considerable variation from simple sliding gate valves to butterfly valves, and the problem of fitting

seals is, in some instances, very difficult and complex. (Figs 6,7 & 8) Some manufacturers use rigid rubber backed plates that can be pulled tight onto the opening by springs, screws or clamps, others a hinged flap with an overcentre lock to hold the plate tight. A cam type lever or clamp is used to hold a rubber backed slide against the outlet. In most cases the edge of the outlet is ground to a sharp angle to prevent any grain being trapped between the outlet and the rubber of the sealing plate.

Another alternative method of sealing the bottom outlet is by a totally enclosed boot that has an access door, also rubber backed, that can be held tight against the outlet by springs or clamps. Some boots are fitted with a slide with a removable handle which, because it is enclosed within the boot the slide does not have to form a seal.

When introducing sealed silos manufacturers also had quality and marketing problems. Farmers had to be pursuaded to pay the additional costs of a sealed silo, about 10-15% or A$300 for a 56 tonne (2,000 bushel) capacity silo. However farmers quickly realised pest control costs were reduced in sealed silos by up to 90% for fumigation and the grain was stored in optimum condition.

There was also concern over testing the efficiency of the seal. Together CBH and APB have promoted the idea of an air pressure decay test for sealed silos. The test standard now accepted is that an inflation pressure of 250 pascals (1000 pascals is equivalent to the pressure of a column of water 1 metre high. 250 pascals is equivalent to a water gauge of 25mm) should not fall to less than 125 pascals in five minutes for new silos (or to fall to 125 pascals in 3 minutes for silos sealed on farms by contractors). This variation is because of the greater problems in sealing silos that have been used. It is difficult to carry out this test reliably because of climatic conditions such as wind, temperature and especially sunlight. The usual procedure is for the manufacturer to test the silo in the factory and for him to give an on-farm test if requested by the farmer. There was some concern that the seal would be damaged during transportation to the farm, but to date there are no known instances of breakdown of the seal during the road journey.

There is also a problem in meeting the CBH/APB recommendation that sealed silos be given a reflective coat during transport. It has now been left to the individual manufacturers whether or not they apply this reflective white coat. Some apply the coat at an extra charge and touch up any transit damage on arrival, others recommend to the farmer that he applies a coat of white acrylic paint after two years when the surface of the galvanising has weathered. Although not nearly so efficient as white, a newly galvanised surface does have an acceptable reflective level. One manufacturer is

experimenting with a white colourbond steel sheeting in an attempt to overcome this problem.

Of the twelve silo manufacturers in Western Australia, only two do not include a sealed model in their current range and one is currently working on a sealed silo for release next year. Sealed silos now account for over 60% of the total market which, in under two years since they first became available, is beyond all expectations. Some manufacturers are producing only sealed silos and others report sales are 60-90% of total production.

Contractor On-farm Sealing

A number of contractors have become established to offer a service to seal existing silos on farms. In the main these contractors were already in the agricultural field in pest control, fencing, spraying, painting or building and the sealing of silos is an extension of these activities.

Initially contractors faced many problems in a new industry and using new materials. These were generally similar to those faced by the silo manufacturers - choice of sealant, application techniques, curing times, replacement or sealing of inlets and outlets, pressure testing and an equitable and acceptable price structure. Many of these problems were discussed with manufacturers and a common solution was found. For instance, many contractors now simply remove all the old inlets and outlets and replace them with new ones supplied by the silo manufacturers. There were some cases of fraudulent practice as some contractors saw substantial gains to be made. In one case a contractor simply painted the silo white, fitted a pressure relief valve and charged for 'sealing'.

In order to overcome these problems and to create an opportunity for the exchange of ideas between all those involved in this field, the APB organised a conference early in 1982.

One outcome of this conference was the formation of the Silo Sealing Association of Western Australia in December 1982. Its aims are to act as a forum, to set and maintain standards and co-ordinate and promote activities in connection with on-farm silo sealing. It has recently adopted a procedure for dealing with disputes on workmanship or any complaints laid by farmers who have had their silo sealed by members of the Association. Contractors are able to take up Business Membership of the Association and nearly all contractors are now members. Associate Membership is offered to suppliers of goods and services used by the industry, such as sealant materials, and to manufacturers producing sealed silos. The Association is now a sectional association of the Confederation of West Australian Industry.

It can be said that solutions can be found to all problems of sealing and contractors can effectively seal any type, model or size of grain silo. By the end of 1982 an estimated 1000 on-farm silos had been sealed by

contractors. Approximate charges for sealing an average 56 tonne (2,000 bushel) capacity silo is between A$750 - A$1,000, including all materials, labour, cement floor treatment if applicable, replacement of all inlets and outlets, pressure relief valve (Fig 9) and application of a reflective white coat.

A contractors' specification for sealing on-farm silos should include:

I. Surface preparation. One of the most important and time consuming operations of silo sealing, essential to ensure good adhesion of the sealants and a reliable seal. Strict attention to cleaning surfaces applies equally for sealing applied internally or externally.

II. Replacement of hatches and outlets usually replaced with new re-sealable units obtained from silo manufacturers. Fittings for the pressure relief valve are added, usually at the top of the silo adjacent to the ladder. A car tyre valve is often fitted into the wall or base cone of the silo to enable the silo to be pressure tested when sealing has been completed. Farmers can also check the seal at regular intervals. With most silos it is necessary to strengthen certain areas, individual roof panels, the eaves and around inlets and outlets usually by rivetting extra metal strips or bands over the joints to hold them together.

III. Filling or taping of the longer gaps using a suitable filler. Alternatively cloth or plastic tape may be used and many contractors successfully use good quality masking tape. Most contractors now tend to use fillers in preference to tape as it is quicker to apply, is equally effective and equivalent in price.

IV. Application of the sealant to all joins in the silo, whether welded or bolted, to a suitable width and thickness. (For acrylics this would be not less than 1mm in thickness and extending at least 30mm each side of the joint). The choice between internal and external sealing is one of personal preference, both will give satisfactory seal if carried out properly. Most contractors now seal externally because it allows them to utilise a greater degree or mechanisation such as the use of self-propelled hydraulic ladders of 'cherry pickers'. It is usually easier and more pleasant to work on the outside of a silo, especially in summer, and it allows greater continuity of work since silos can be sealed externally even when they are full. Most contractors using the water based modified acrylics apply these with an airless spray operating at a pressure of around 7,000 kPa (or 1,000 psi), but some of

the smaller contractors apply the sealant with an ordinary paint brush.

V. Application of a reflective acrylic white paint coating to all external surfaces of the silo.

VI. Pressure testing when sealing has been completed. Even the most experienced contractor has a success rate of less than 10% at the first test so any silo not tested is probably not sealed. The minimum acceptable standard for existing silos sealed on-farms is that a pressure of 250 pascals should not fall to less than 125 pascals in three minutes. (This is less than the five minutes for new silos because of the additional problems involved in sealing these structures). As with factory built silos, this test must only be carried out when climatic conditions are stable. It is important not to exceed a pressure of 300 pascals in the silo to avoid possible damage to the sealant or structure.

Farmer Application

The degree of attention to detail and the dedication required to seal a farm silo to the recommended standard is daunting to most farmers. 50 farmers only are believed to have completed the job and saved about A$300-A$400 per silo. Some farmers are known to have been unable to complete the sealing to a satisfactory standard and a few even employed contractors to finish the job.

A recent development is the sale of complete silo sealing kits by members of the Silo Sealing Association to farmers who want to carry out the sealing work themselves. The kits contain the correct amount of sealant for the farmers particular type of silo, together will all necessary fittings, outlets, inlets, filler, tape, etc. The member will also give advice on sealing technqiues.

Trends in Silo Sealing for On-farm Use

The acceptance by farmers of the concept of sealed storage for efficient on-farm fumigation has exceeded all expectations. Sales of new sealed silos are well ahead of unsealed models and prior to November 1982 it was impossible to arrange for any contractor to carry out on-farm sealing of silos for at least four months because all had full order books. However, there are some areas of Western Australia with only a few farms with sealed silos. The reasons for this are not fully understood. It may be due to the costs of having an existing silo sealed or the extra cost of a sealed model together with a lack of understanding of problems of stored grain insect control and the financial benefits of sealed storage. There were initial difficulties with both manufactured and contractor sealed silos due to lack of experience in

new techniques and these difficulties may be used to discredit sealed silos by agents and manufacturers still selling unsealed models. The most likely cause may be the uneven distribution of contractors throughout the State so that in some areas contractors are unavailable, or travelling and accommodation charges make the cost prohibitive.

It is now a major concern that some silo manufacturers are advertising "semi-sealed" silos. These are not tested to APB/CBH recommendations, often the outlets and inlets are not re-sealable and unproven materials have been used to cover joints. One manufacturer used car underbody sealer. Unfortunately, there is little than can be done to prevent this practice although officers from the APB and Silo Sealing Association have visited these firms in an attempt to get them to voluntarily come into line. Our fear is that if farmers use recommended dosage rates of fumigant for sealed silos in a so-called "semi-sealed" silo, only a low level of control will be achieved and farmers' faith in the efficacy of sealed storage will weaken.

It is claimed that grain is damaged due to moisture migration within the silo. Whilst it is accepted that this phenomenon may be accentuated in a sealed silo, if the grain is at an acceptable moisture content (less than 12%) migration is unlikely to occur. However, farmers often store grain, rejected at the CBH receival point because of high moisture content, in their on-farm silo. This practice makes migration inevitable with the risk of associated grain spoilage. It is in this instance that sealed storage will be blamed. The solution appears to be in educating farmers in the dangers of storing damp grain, particularly in a sealed silo.

Some farmers believe that because grain is stored in sealed silos it is safe from insect attack, and no other control measures are needed. The extension programme has now to return to the elements of stored grain insect control to re-stress the importance of the clean pipeline concept, to increase its efforts to pursuade farmers to pay more attention to farm hygiene and to emphasise that silo sealing is only part of good farm hygiene, not a substitute for it.

In the past two years the picture of grain storage in Western Australia has changed dramatically. For the first time there appears to be an opportunity to maintain stored grain free of insect pests. Looking to the future it seems likely there will be wider farmer acceptance of sealed storage. The sealing, in 1982, of a further 19 country bulk stores by CBH has illustrated dramatically to farmers that organisation's commitment to these techniques and this has led to an increase in demand for sealed silos in these areas.

Farmers have accepted sealed storage to enable them to undertake efficient phosphine fumigation. If, in the future, it becomes necessary,

because of increasing insect resistance or public health requirements, to change to using inert gases and controlled atmosphere storage, the Western Australian farmers who have previously adopted sealed storage will be able easily to adopt these new techniques.

I am convinced that the development of sealed storage has been adopted readily, not so much because Western Australian farmers are vitally concerned with the problem and are by nature progressive, but because this technique has been researched, developed and promoted by all those in the grain industry, farmers, farmer organisations, Department of Agriculture, Co-operative Bulk Handling and Agriculture Protection Board. These bodies have worked together to solve a common problem, unacceptable insect damage in stored grain.

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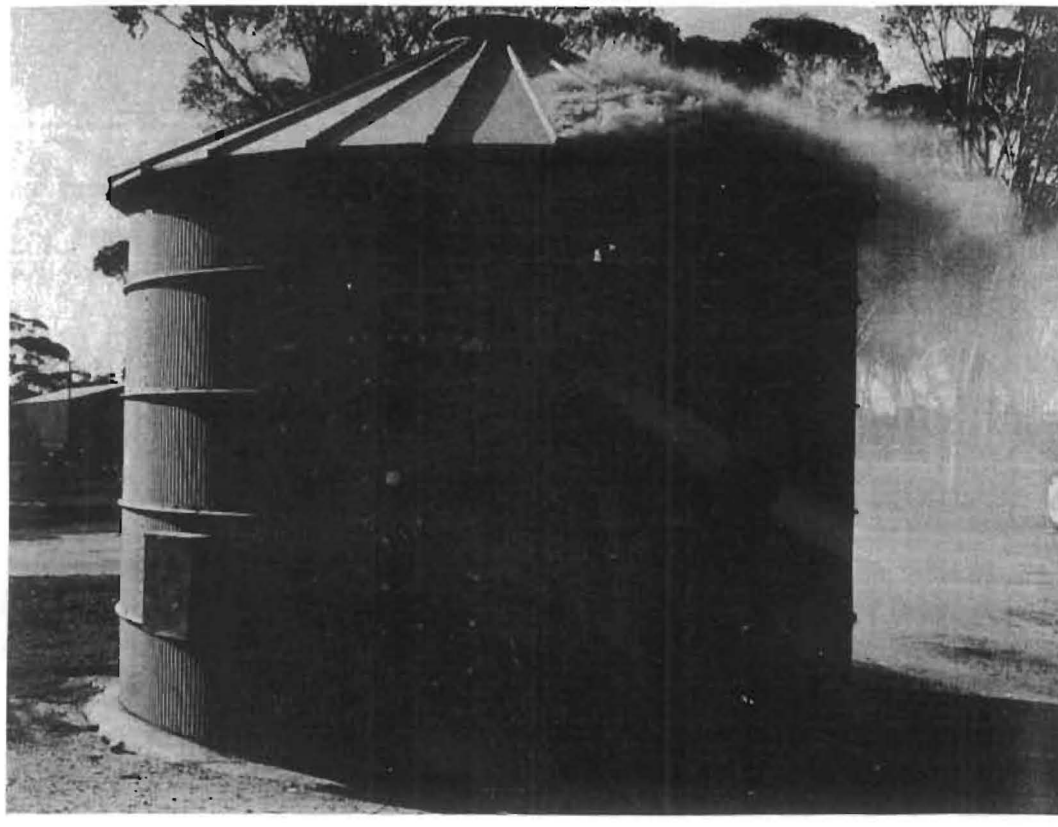


Fig. 2 Smoke escaping from joins of an unsealed farm silo.

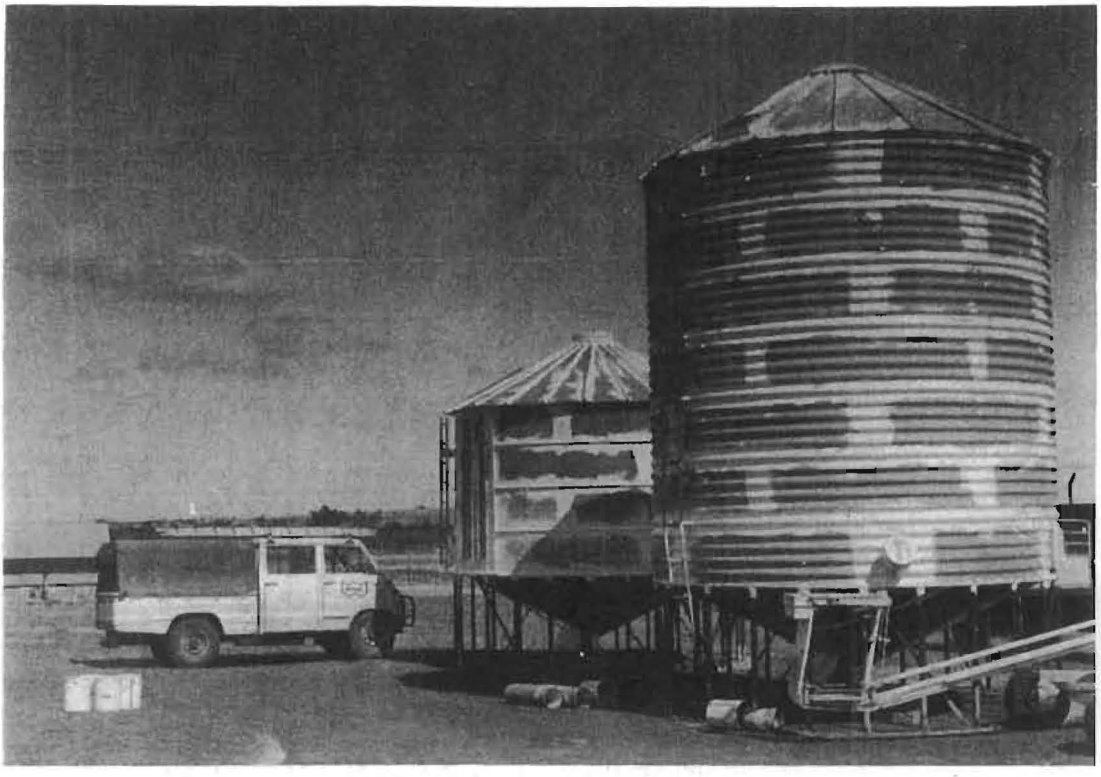
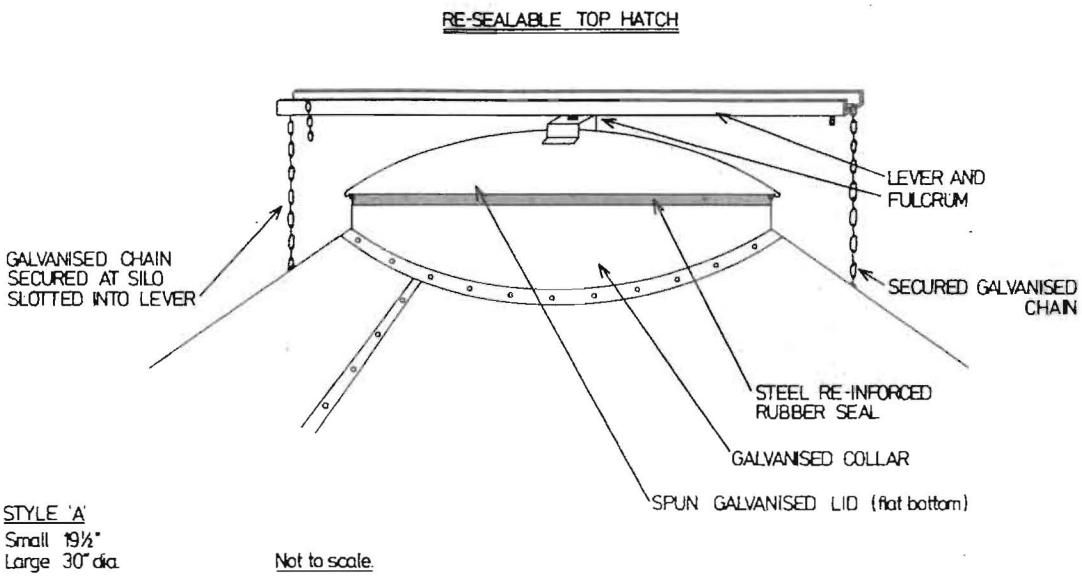


Fig. 3 Sealing of joins in on-site farm silos.

Fig. 4 Application of reflective coat to sealed silos.



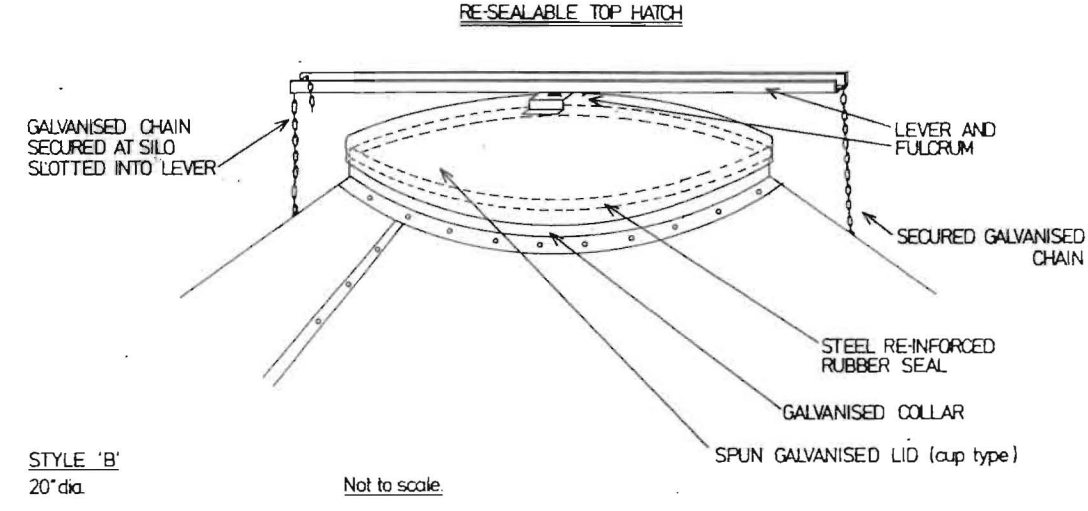


Fig. 5 Designs for sealable top hatches for farm bins.

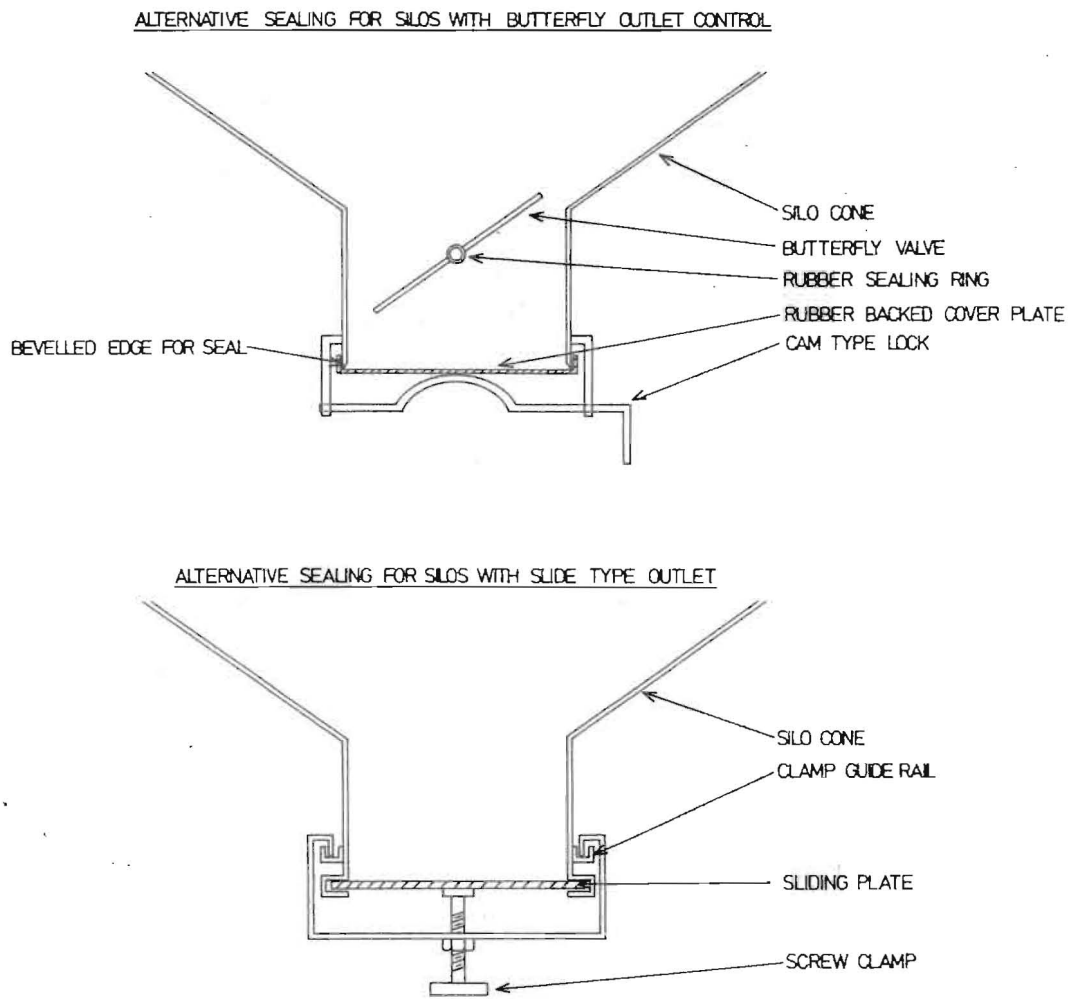


Fig. 6 Sealing systems for outloading chutes for farm bins.

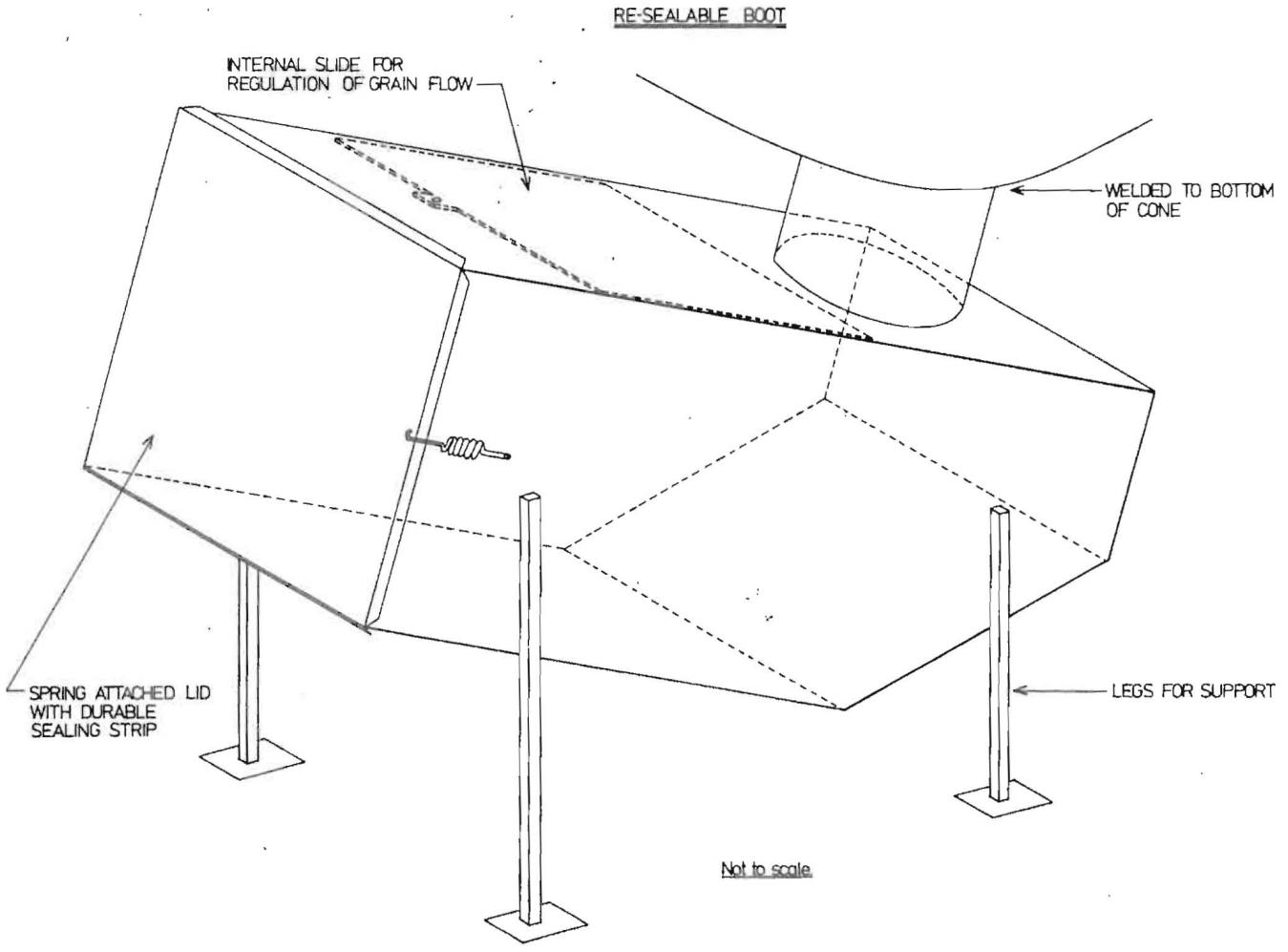


Fig. 7 Design for a resealable auger boot.

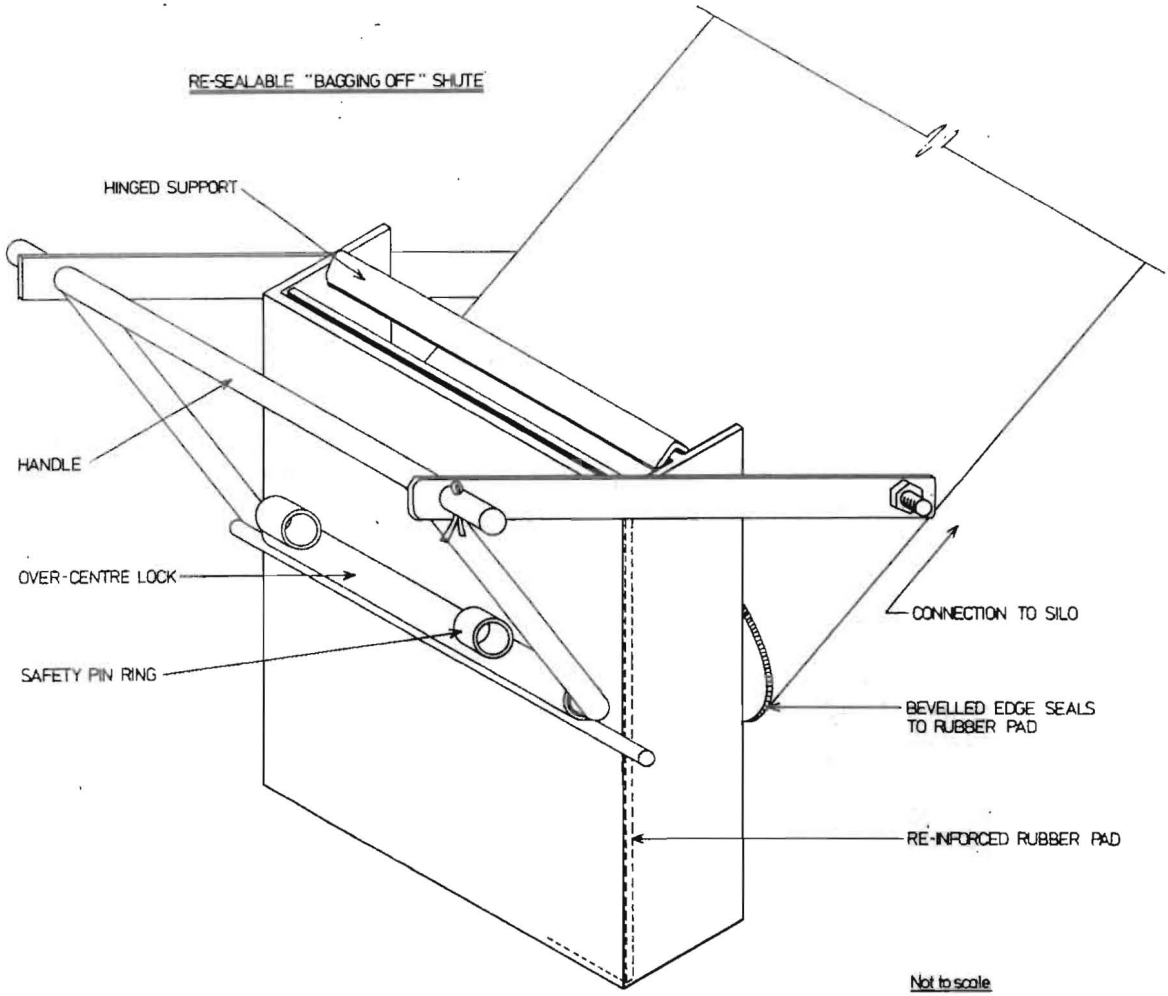


Fig. 8 Design for a sealable bagging-off chute for a farm bin.

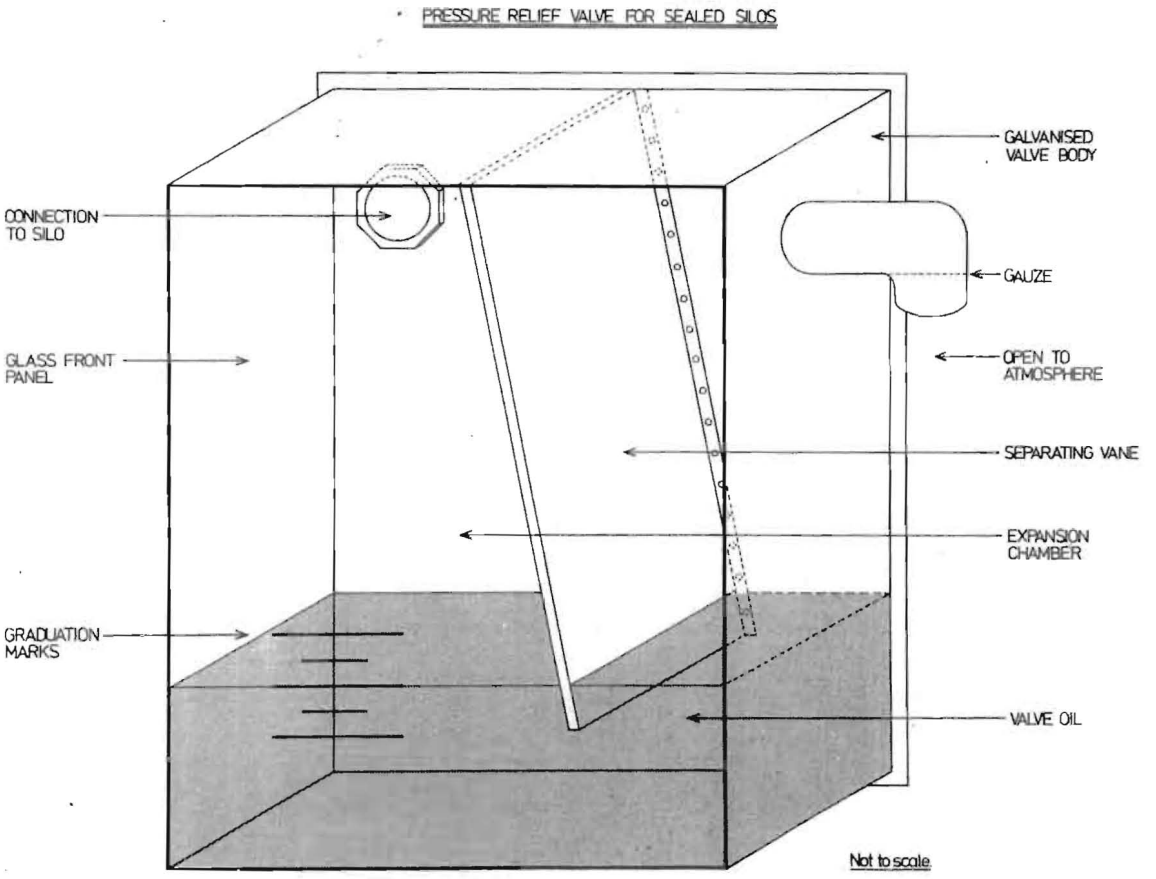


Fig. 9 Design of an oil-filled pressure relief valve for a farm bin.