

Short Term Leaflet 21  
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# HOT WATER TREATMENT OF NARCISSUS BULBS



MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

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## HOT WATER TREATMENT OF NARCISSUS BULBS

Hot water treatment (HWT) coupled with crop rotation is the only commercial method of controlling stem and bulb eelworm\* in narcissus bulbs. It is important to ensure that the HWT is carefully carried out as the margin between killing the eelworms and damaging the bulbs is small. This leaflet therefore concentrates on the control of eelworms although HWT will also control bulb scale mite\*\* and the maggots (larvae) of both large♄ and small♅ narcissus flies.

After two years growth in the field all narcissus bulbs are normally hot water treated to control eelworm during the period between lifting and replanting. Although these stocks are called 'clean' it is assumed that they may carry a low population of eelworm despite the absence of symptoms of eelworm damage in the previous growing season. HWT of these bulbs is an essential insurance against a build up from this low population. All new bulb stocks brought on to the farm should also be treated.

Infestations in obviously infested crops are not so easily controlled because after lifting the eelworms rapidly form 'wool', which can sometimes be seen as creamy-white clusters on the outside of the bulb. This wool is very resistant to HWT.

The only satisfactory method of treating such heavily infested bulb stocks is by roguing in the field at the height of the growing season to remove all plants showing symptoms plus adjacent bulbs followed by early lifting before the crop dies down and the eelworms become resistant. This should be followed by very early HWT. If the crop is very heavily infested destruction of the stock is often the best procedure.

In HWT of narcissus bulbs there are broad differences between the two main growing areas of England. In the south-west, outdoor flower production is very important and growers take precautions to preserve

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\* *Ditylenchus dipsaci* (Kuhn) Filipjev see Advisory Leaflet 460.

\*\* *Stenotarsonemus laticeps* (Halb)

♄ *Merodon equestris* (F)

♅ *Eumerus strigatus* (Fall) and *E. tuberculatus* (Rond) see Advisory Leaflet 183.

the first year flower crop from HWT damage. In eastern England growers are less concerned with flower damage as bulb production is of greater importance. The basic requirements for eelworm control are similar for both areas, the differences in treatment being in such ancillary processes as pre-warming and pre-soaking.

### **HWT Specifications**

*Standard HWT* is three hours at 44.4°C.

*High temperature HWT* is three hours at 46.7°C and is only used in conjunction with pre-warming and pre-soaking (see below) when a first year flower crop is planned.

Both systems require the use of formalin plus wetter as additives for the more efficient control of pests and disease (see page 8 ). The timing of treatment starts when the water temperature has stabilised at the required level.

Bulbs held in store at low ambient temperature are frequently damaged by HWT. Leaf damage occurs especially with late treatment, and the flowers are usually deformed to some extent although this does not affect bulb yield. The most serious damage occurs to bulbs held in cool damp conditions when they start to root. Loss of these roots in HWT can seriously affect the vigour of the stock.

#### *Pre-warming to 18°C*

The damage described above is most serious following storage below 18°C. If stocks can be stored under cover or in controlled temperature stores at or slightly above 18°C serious plant and root damage can be avoided. As the mean temperature in the UK during August may be only 15-16°C storage of bulbs without protection before HWT usually entails the risk of considerable damage.

#### *Pre-warming to 30°C*

Pre-warming to 30°C prevents flower, leaf and root damage. The flowers are not usually of top quality but are saleable. This process is therefore used in areas of early flower production and in those cases where HWT damage must be avoided.

Storage for seven days at 30°C enables the bulbs to be safely hot water treated at higher temperatures, but it increases the resistance of

eelworm to heat. Thus, warm storage at 30°C is always followed by higher temperature HWT at 46.7°C and this is always preceded by pre-soaking which helps to counteract this resistance.

#### *Pre-soaking*

Pre-soaking is always used where bulbs have been pre-warmed at 30°C. Bulbs are immersed for three hours (or over-night if convenient) in water at ambient temperature using additives as for HWT. This process activates eelworms which may have reached the 'wool' stage making them more susceptible to HWT.

#### **Stage of Bulb Development in Relation to HWT**

Before the foliage has died down the buds for next year's flowers within the bulb have started to develop. From this stage onwards the various floral parts will form in succession and the internal stage of development (ISD) can be assessed at any time by dissecting out the developing bud and observing it with a x 10 hand lens or low power microscope. These stages of development are illustrated and the dissection technique described in Technical Bulletin 22 *Internal Stages of Bulb Development*\*.

The final floral part to be differentiated is the trumpet or paracorolla and when this is clearly visible as a short frill outside the base of the anthers, the bulb is said to have reached stage Pc.

In the absence of pre-warming treatment HWT well in advance of stage Pc will cause 'blind' flower buds but if carried out nearer to stage Pc the damage may consist only of a split trumpet and ragged perianth, nevertheless rendering the flowers unsaleable. Very late treatment, well after stage Pc, will cause 'dead' buds. As cool and damp conditions after stage Pc encourage root development the effects of late HWT can be very damaging by killing the roots. Every effort should be made to prevent premature rooting in bulbs intended for treatment by keeping them dry and reasonably warm. A holding temperature of 18°C is satisfactory.

Blotched foliage in the first season after HWT is an indication that treatment was carried out later than it should have been. Although slight blotching does not indicate that sufficient damage has been done

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\* Available from bookshops or HMSO, PO Box 568, London SE1 9NH price 17½p net.

to affect the vigour of the stock it suggests that either treatment should in future be earlier, or the storage conditions improved. Cool conditions before treatment will increase the amount of marking on the leaves and late treatment after cool conditions may result in leaf distortion.

### **Timing of HWT**

The safest time for minimum leaf, flower and root damage is shortly after the bulbs have completely formed the flower initials (stage Pc). There is some variation between varieties, localities and seasons (up to 15 days) in the date when stage Pc is reached but for the main varieties the average for the south-west is mid-July and for the eastern counties late July or early August. In the south-west therefore HWT should be carried out from late July to mid-August and in the eastern counties from early to late August. The end of the HWT season is determined by the date at which active root growth starts. Given reasonably dry and warm storage, severe HWT damage is unlikely at these times.

Earlier treatment is justified under the following circumstances:

1. Ex-forced bulbs (which die down early) are usually treated in May or June.
2. Eelworm infested stocks which should be lifted early are treated in June or early July.
3. Standard HWT, where first year flowers are not required, can start as soon as the bulbs have been cleaned and graded. Where large quantities are being handled this ensures a timely finish to the HWT season.

### **Order of HWT for Varieties**

Those narcissus most susceptible to damage by HWT are *N. poeticus ornatus* and *N. Double White*. These must be treated early and providing the stock is 'clean' warm storage at 30°C should precede treatment to reduce the risk of damage. Varieties most closely related to the above, that is, the short cupped types, come next in order of susceptibility and so are treated before the large cups; which are followed by the trumpet varieties.

### **Layout of plant**

The requirements laid down for HWT are precise and can be easily upset by unsuitable conditions. To obviate this the following points should be observed:

1. The treatment tank should be installed in a building to give protection against draughts that tend to cool the tank unevenly and spread bulb debris which may contain eelworms.
2. The layout should be planned so that the movement of bulbs is one way only, preferably against the direction of the prevailing wind. The untreated (dirty) bulbs should be cleaned and graded either in a separate building or in a screened off area of the shed well separated from the hot-water treated (clean) bulbs. Soil and debris from the cleaner is best collected into a screened area or a pit so as to minimise its spread.
3. The building should be easy to keep clean. This entails having floors and walls with hard smooth surfaces and adequate drainage to allow washing down. A flush interior finish and a high clear span facilitate cleaning and the handling of the bulbs.

The tank should be easily accessible for mechanical loading, the ideal system being an overhead track and travelling hoist with sliding partitions on either side of the treatment tanks which prevent draughts and minimise traffic and movement of workers between the dirty and clean sections. With new installations it is as well to allow for the possibility of extra tanks being installed at some future date.

Recently, front loading tanks have been installed on some bulb farms. These need special attention to hygiene since both 'dirty' and 'clean' bulbs travel over the same ground.

4. A sterilant should be used for washing down the walls, floors, vehicles and fork-lift trucks. Even if different vehicles are used to handle 'dirty' and 'clean' bulbs this is a wise precaution. Similarly bulb trays should be disinfected at least once annually.

Solubilised cresylic acid\* is a convenient and effective sterilant. Treated equipment and trays must be thoroughly dried before coming into contact with bulbs or damage may result.

### **Types and Design of Tank**

Modern tanks are square or rectangular for most efficient use with pallet or pallet-bin loads of bulbs. Tank dimensions should be chosen to suit those of the container being used. Pumped circulation is essential to ensure even distribution of the water from the heaters, which must be thermostatically controlled at a precise temperature setting.

The tank should be well insulated with a water impervious material, for example expanded polystyrene suitably protected against mechanical damage. An insulated lid is also essential.

### **Tank Capacity and Pump Size**

The tank should contain at least twice and preferably three times as much water as bulbs, weight for weight. For example, a tank designed to heat one tonne (one ton) of bulbs should contain at least 2000 litre and preferably, 3000 litre (450-670 gal) water.

Circulating pumps must give at least five changes of water per hour, for example, for a tank containing 3000 litre water, the pump must be rated at a minimum of 15 000 litre/hour or 250 litre/min. (The working pressure will be about 1.5 Kpa (5 ft) head.) Higher pumping rates can be used, and are advisable to reduce temperature variations especially when less satisfactory containers (like nets) are used to hold the bulbs.

It is advisable to have filters on the suction side of the pump to remove bulb debris. Such filters must be of such a size and design that water flow is not impeded to avoid a reduction in pump output which may lead to uneven temperatures and the formation of excess foam. Filters should be easy to clean without interrupting the action of the pump.

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\* This is made up by mixing a wetter (of the type sold as 21 per cent of the sodium salts of secondary alkyl sulphates) with the cresylic acid. To one part by volume of the wetter is added a few parts of water, this is mixed, and then one part of cresylic acid is added. The mixture is well stirred and made up to 100 parts by volume with water.

## Heating

There are three main methods of heating the tank; steam, electricity or direct heaters using gas or oil burners. If steam is available this may be used direct or through a coil for initial heating up, with thermostatically controlled electrical heaters or hot water from a steam calorifier giving the precise control required during treatment. The use of oil fired burners is increasing and they can perform both the initial heating up and controlled heating, provided they are installed by a specialist; earlier difficulties with this type of heating have been largely overcome by improved pump circulation.

The thermostat required is one with a short temperature range (usually 26-60°C) to give maximum sensitivity. Even the best control unit may suffer from scale error, and must always be checked against an accurate mercury-in-glass thermometer, which itself should be checked against a thermometer tested and approved to standards laid down by the British Standards Institution.

Water loss can be made up from a small header tank. Where fitted, it is usual for this to be pre-heated electrically and maintained at around 60°C.

## Design

Tank design requires specialist engineering knowledge and must start with the grower's estimate of the throughput required, and a clear picture of the handling system to be adopted. Including a warming up period and changing over loads, each complete treatment (or 'cook') can take up to four hours. Thus only two 'cooks' can be completed in a normal working day. As ideally, HWT should be completed on any farm within about one month, this gives the basis for calculating the number of tanks required and their capacity.

## Tank Type

Two basic types of tank are in current use, and these are illustrated in Appendix 1

### a. *Top loading*

This is the more traditional type, the water remaining in the tank between loads. Bulbs are loaded into the tank by an overhead hoist, or fork-lift truck, the pallets or bins being fitted with removable lifting gear immediately beforehand.

b. *Front loading*

This newer type of tank is designed for use with fork-lift trucks. The water is pumped out between loads into a 'slave' or holding tank, to enable the front of the tank to be opened on hinges or moved aside on rails. A false bottom to the tank, at floor level, enables pallets to be driven into position for treatment.

For both types, heating systems are largely interchangeable, though those in the illustrations are typical examples for each type of tank. For economy in labour, and maximum throughput, it is usual to operate both types of tank in pairs, unloading and reloading one whilst the other is 'cooking'.

### **Types of Load**

There are three basic types : palletised nets, palletised trays and bulk bins (see Appendix 2). The dimensions of the load and the tank need careful planning so as to maximise throughput of the tank without exceeding the 1 : 3 bulb weight to water weight ratio. Also the method of handling the bulbs and the system of storage before and after HWT must be considered as an integral part of the process.

### **Additives to HWT Tanks**

Reference has been made to wetter and formalin (formaldehyde). Both these additives play an important role in eelworm control and should always be added to any pre-soak or HWT tank regardless of whatever other chemicals are used.

Wetter or spreader (preferably of the non-ionic type commonly sold for horticultural use) should be added at the manufacturer's recommended rate. The wetter is required to ensure the thorough wetting of eelworm 'wool' which reduces its resistance to heat.

Formalin (a 40 per cent solution of formaldehyde) is added at one litre in 200 litre water (4 pt/100 gal). Formalin is particularly important as it kills free swimming eelworms in the tank which are not adequately controlled by heat alone and it controls the spores of *Fusarium* (basal rot) which could otherwise spread to healthy bulbs via the water.

Foam on the water is dangerous. It usually contains debris and is at a lower temperature than the water so allowing eelworms to survive. Recently anti-foaming agents have been tested. 'Antifoam' (Duphar-Midox) and DB 31 (Dow-Corning), are safe and may be added at the

manufacturer's recommended rate where foam is a problem. Foaming usually occurs when air is being sucked into the circulation system, for example when water does not completely cover the suction inlets or when the water outlet is above the water level in the tank.

If the tank requires topping up the solution should contain the normal concentration of additives.

The use of organo-mercury compounds is on the decline. Their use is only permitted in premises registered under the Factories Act and there are statutory obligations affecting employers and workers using these compounds.

### **HWT Operation**

The tank should never be overloaded with bulbs and the use of a palletised system and rigid containers is a useful safeguard against this occurring.

Before immersing the load, the water is heated a few degrees above the required treatment temperature with the circulating pump operating. The amount of 'over-heating' required depends upon a number of factors, but could be about 3°C, for example, heat to 47.4°C for a 44.4°C treatment. This counteracts any tendency for the water to drop well below the treatment temperature after loading and therefore saves time. Ideally the water temperature should be about one degree C below target temperature after loading so that only a short period of heating is needed. The treatment can only be considered to have started when the target temperature has been reached throughout the mass of water in the tank. This is usually checked in practice by observing the trace on a thermograph temperature recorder fitted into the circulation system. But frequent checks *must* be made on the accuracy of these instruments using an accurate mercury-in-glass thermometer as outlined earlier. The warm-up period usually takes about half an hour, giving a total immersion time of about 3½ hours.

### **After Treatment**

After treatment the bulbs should be cooled as quickly as possible, and unless they are to be planted immediately, they should also be re-dried. Cooling and re-drying must be done away from sources of re-contamination.

Bulbs in trays will cool rapidly, and dry off at the same time, particularly if placed in a good draught. Bulbs in nets on pallets have also been shown to cool off and dry well following HWT, provided the pallets are stored singly in a well ventilated area having a good through draught. (The heat remaining in the bulbs from HWT helps to evaporate the surface water remaining from the treatment.) Otherwise, the nets must be placed singly to cool off and dry.

Bulbs in bulk in pallet-bins must be provided with forced draught, and a convenient way is to blow the air through the pallet bases of a line of bins from a small fan fitted with a suitable adaptor, (after the manner of the drying wall system). Alternatively, if available, a partitioned off section of an existing drying wall can be used. 425 m<sup>3</sup>/h of air per tonne (250 cu. ft/min/ton) is ample for this purpose. If bulbs in the centre of loads remain warm and wet, not only is the HWT prolonged for an unknown period, but such conditions favour the development of *Fusarium* (basal rot) and soft rot (associated with *Rhizopus*).

Since, within limits, early planting is advantageous, prompt planting is the best method of preventing re-contamination and also avoids problems of damp bulbs deteriorating.

### **Summary of HWT Programmes**

#### Eelworm infested stocks

- Remove obviously infested bulbs by roguing in the field
- Lift early and sort the bulbs
- Pre-soak if possible although this may increase HWT damage\*
- HWT early for 3 hours at 44.4°C\*

#### 'Clean' stock with no visible infestation

- a. First year flowers not required:
  - HWT for 3 hours at 44.4°C\*
- b. First year flowers required:
  - Warm store for 7 days at 30°C
  - Pre-soak for 3 hours (or overnight)\*
  - HWT for 3 hours at 46.7°C\*

\* Additives in all these processes include a non-ionic wetter diluted to the manufacturer's recommended rate and formalin at one litre per 200 litre of water.

## Conclusion

Narcissus eelworm is a very serious pest and once established often proves very difficult to eradicate. In view of this it is preferable in the long term to aim for good control as a first priority and on occasions be prepared to abandon the first season's flowers. Experience shows that any attempt to reduce damage or to preserve the flowers by warm storing of visibly infested stocks, treating at lower temperatures or for shorter durations, results in the perpetuation of an eelworm problem. In time the infestation becomes widely distributed over the land and in the buildings so that control is then virtually impossible.

In view of the long term implications of eelworm and the range of equipment and techniques available for its control, growers should take every opportunity of consulting the local ADAS horticultural advisory officer for detailed advice on the use of HWT.

## Temperature Conversion Chart

°C	°F
9.0	48.0
15.0	59.0
18.0	64.4
30.0	86.0
35.0	95.0
44.4	112.0
45.6	114.0
46.7	116.0

## Ministry Publications

Advisory leaflet 460 *Stem Eelworm of Narcissus* - single copies available free from any Ministry office or from the address on the back cover.

Bulletin 201 *Hot-Water Treatment of Plant Material* - 42p net.

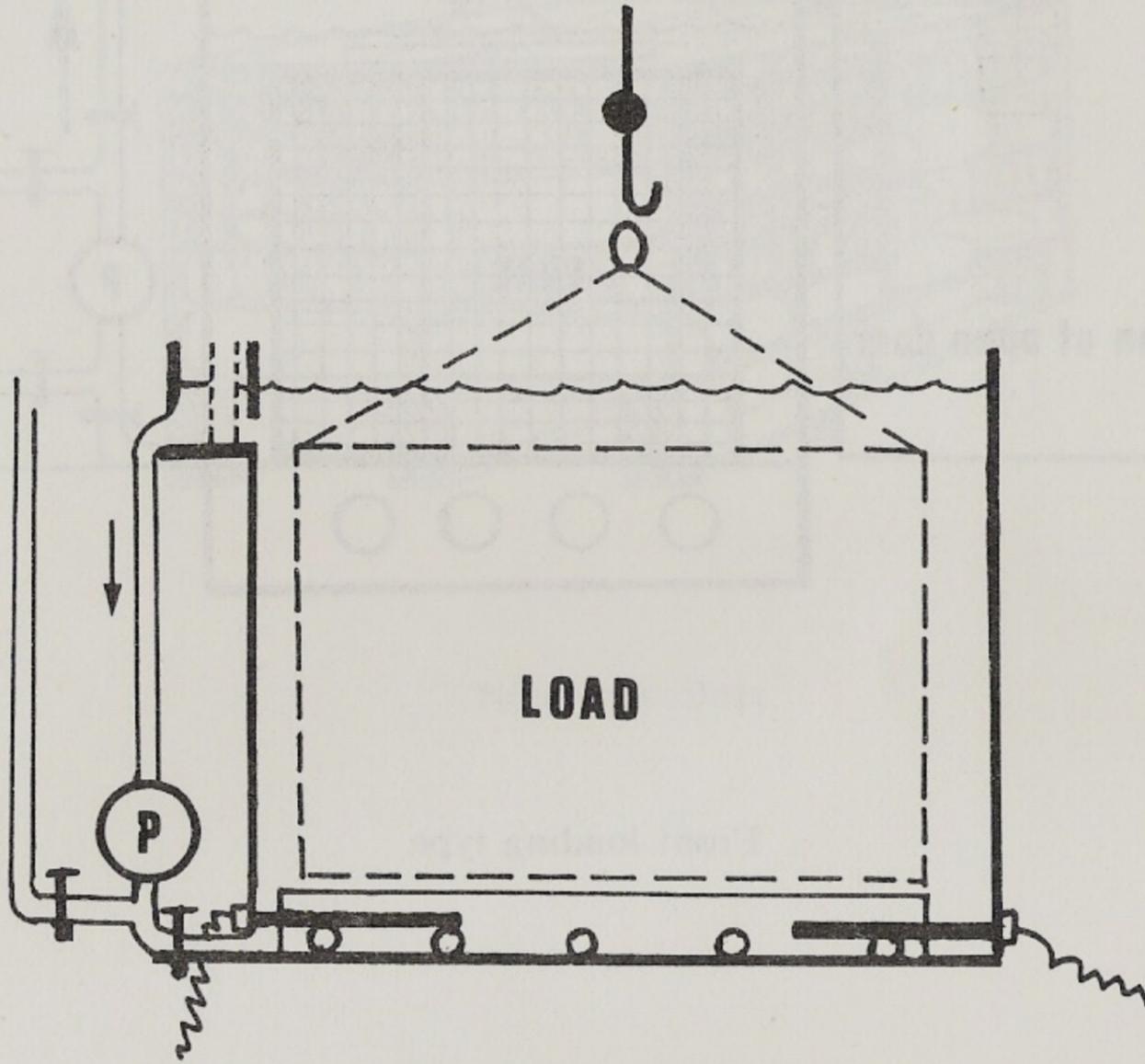
Technical Bulletin 22 *Internal Stages of Bulb Development* - 17½p net.

## APPENDIX 1

### TYPES OF HWT TANK

#### Top loading type

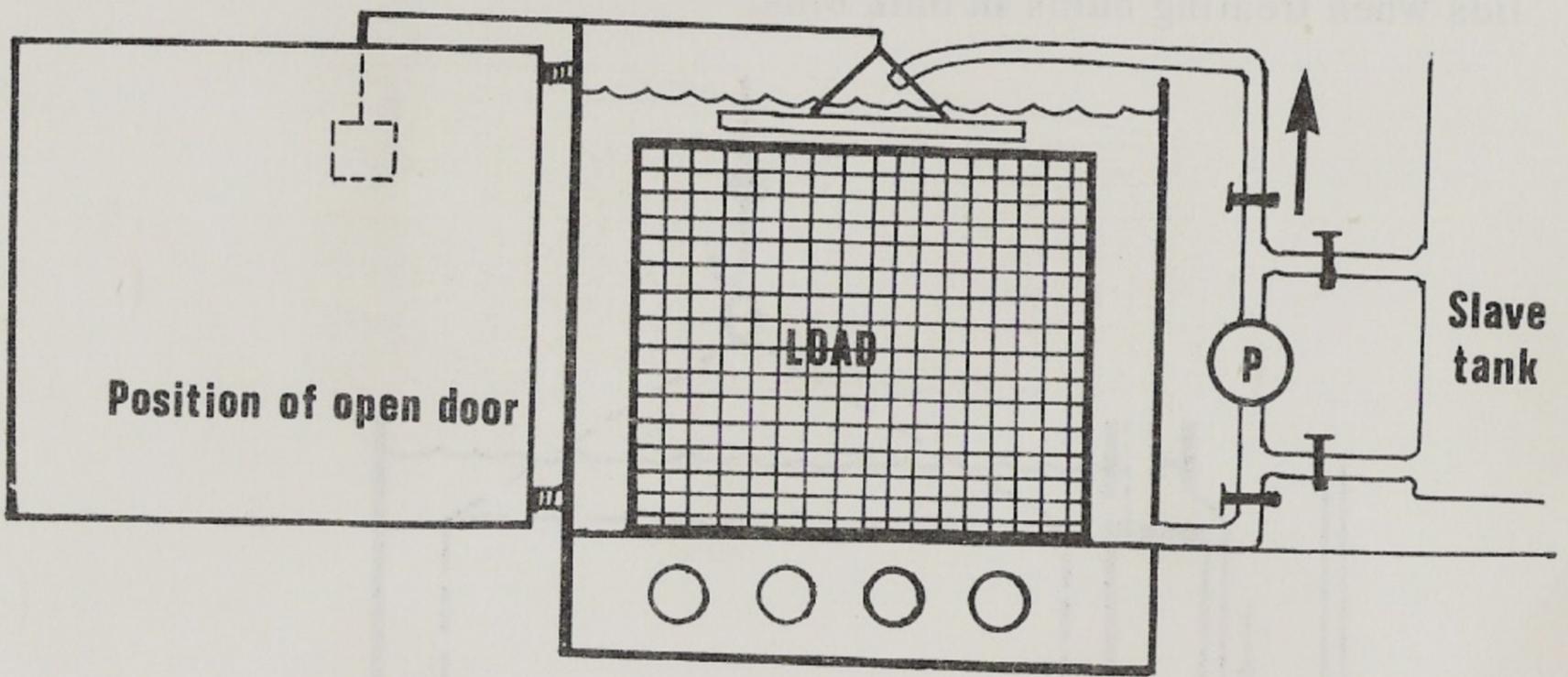
Top loading tanks usually employ a travelling hoist for loading. The water may be heated by steam, oil or gas fired burner or electricity but thermostatically controlled electric heaters are normally used for control during treatment. Water circulation is from the top of the tank via filter plates to the pump and then into the grid at the bottom. The additional valved outlet on the left hand side is to supply water to the lids when treating bulbs in bulk bins.



Top loading type

### Front loading type

The front loading type of tank has a perforated floor at ground level so that the tank can be loaded by fork-lift truck. A large pump provides circulation and removes the water into a slave tank to permit the sliding front of the tank to be opened. Heating is via a thermostatically controlled oil or gas burner with flues situated in a heating chamber beneath the load. Water circulates from the base of the chamber to inlets positioned either above the load or on to the top edges of the tank. A counterbalance weight prevents any tendency to float.



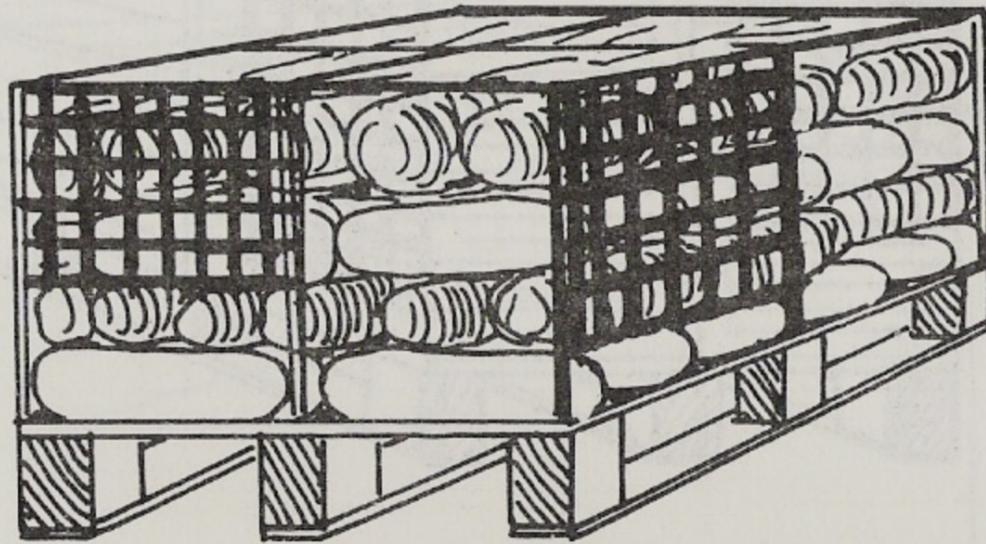
Front loading type

## APPENDIX 2

### TYPES OF LOAD

#### 1. Nets on pallets

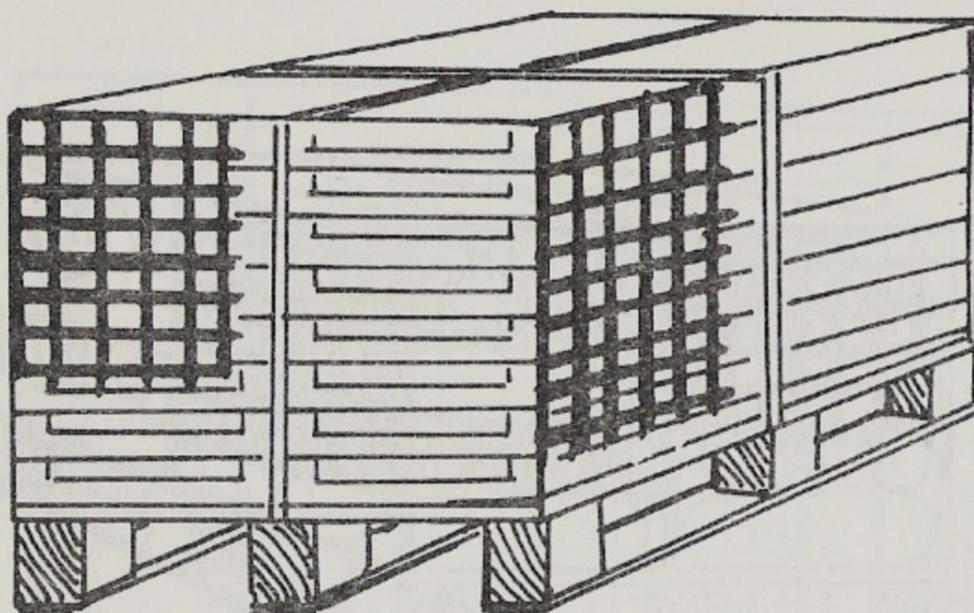
Nets stacked on pallets are one of the least efficient systems but with 'open' stacking, large mesh nets and good pump capacity, they can be satisfactory. Side framing is used to support the load. After removal from HWT the bulbs in the centres of nets may rapidly deteriorate unless spread out to cool and dry.



Nets on pallets

## 2. Trays on pallets

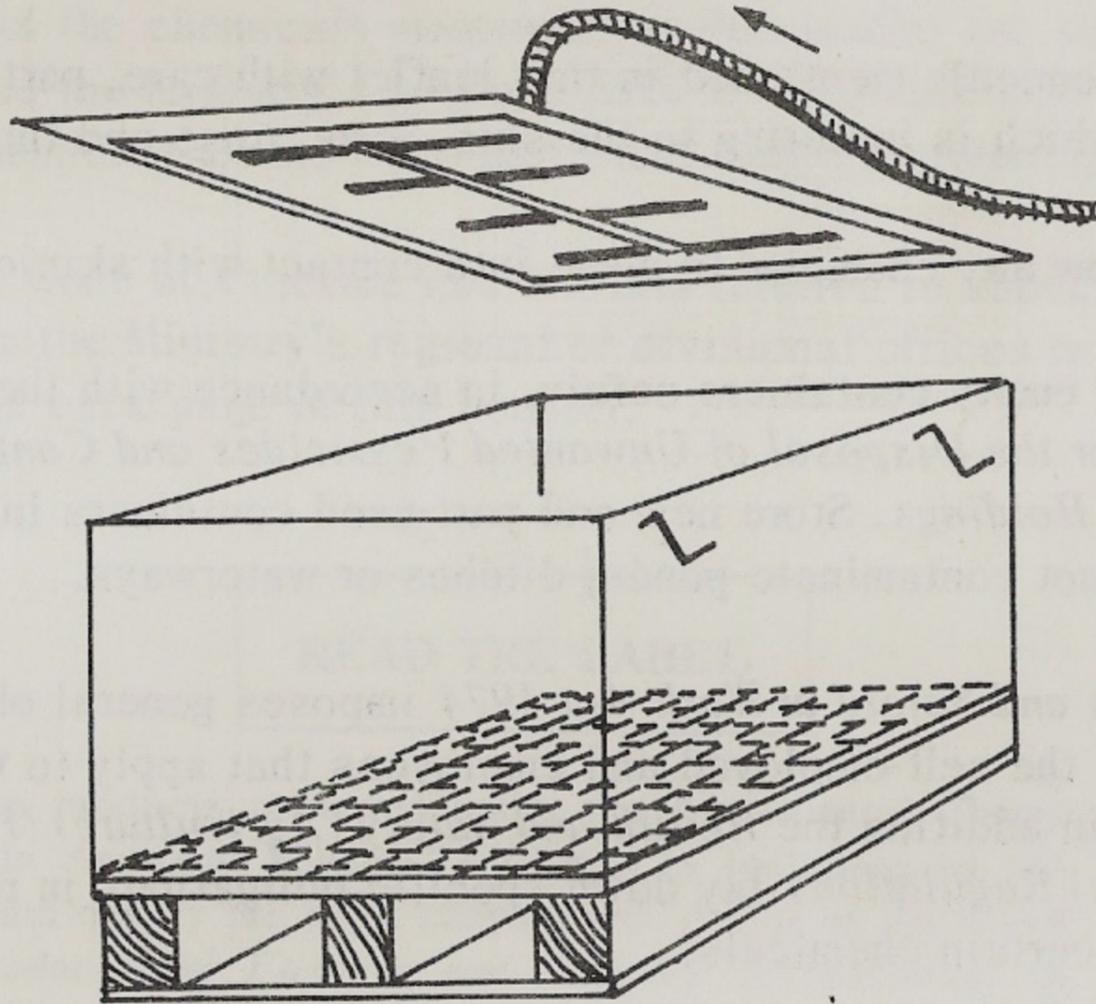
Trays stood on pallets are a good system provided the trays are not overfilled. The bulbs may be loose in the trays if the whole load is caged over to avoid floating - failing this the bulbs should be contained in nets within each tray. After removal from HWT the bulbs will dry off without re-stacking.



Trays on pallets

### 3. Bulk bins

Bulk bins are an efficient system provided the water is made to circulate through the bin. One method is to seal the top of the bin with a lid which carries a distribution grid on its underside into which water is pumped. Bins have solid sides and a mesh base. Other methods are being developed. After removal from HWT the bulbs must be cooled and dried using ducted air. The drawing shows the detail of the underside of the lid and hose connection to circulating pump.



Bulk bins

## PRECAUTIONS

Whenever chemicals are used, **follow the instructions given on the label** on strength and frequency of application of the chemical and observe the recommended minimum intervals between application and planting or handling the crop. **Read and follow carefully the Safety Precautions on the label.** These should be as in the *Recommendations for the Safe Use of Chemical Compounds Used in Agriculture and Food Storage*, issued on individual chemicals and uses by the Ministry of Agriculture, Fisheries and Food following clearance under the Pesticides Safety Precautions Scheme.

Use the chemicals mentioned in this leaflet with care, particularly formalin, which is irritating to the skin, eyes, nose and throat.

Do not allow any chemical to come into contact with skin or clothing.

**Dispose of empty containers safely**, in accordance with the *Code of Practice for the Disposal of Unwanted Pesticides and Containers on Farms and Holdings*. Store new and part-used containers in a secure place. Do not contaminate ponds, ditches or waterways.

*The Health and Safety at Work Act 1974* imposes general obligations on employers, the self-employed and employees that apply to work with any chemical. In addition the *Health and Safety (Agriculture) (Poisonous Substances) Regulations* lay down specific obligations in relation to the use of certain chemicals.

Bulb growers are warned of the risks of using organo-mercury bulb dips. Organo-mercury preparations are perfectly odourless in use and one of their main dangers is that the effects of poisoning are not immediately apparent. Persons exposed to vapour from the dips or whose skin is contaminated by the liquid may suffer from damage to the nervous system and the kidneys. Apart from the suffering involved, the poisoning is often irreversible and can result in permanent incapacity for work. Because of these dangers, organo-mercury bulb dips should only be used in premises registered under the Factories Act, where regular expert inspections can ensure that the right precautions are taken against a build-up of concentrations of mercury in the atmosphere, that the processes used are safe, and that proper protective clothing is worn.

## Protection of Consumers

To ensure that a harvested crop does not contain any harmful pesticide residue, follow the instructions given on the label on the strength and frequency of application of a pesticide and observe the minimum intervals between the last application and harvesting.

The Pharmacy and Poisons Act 1933 imposes specific provisions for the labelling, storage and sale of scheduled poisons including formalin.

Users of any of the chemicals mentioned in this leaflet are strongly advised to read the Ministry's leaflets APS/1, *The Safe Use of Poisonous Chemicals on the Farm* and *Take Care When you Spray!*

Copies of the Code of Practice and leaflets referred to above are available from the Ministry's regional or divisional offices or from the address on the back page of this booklet.

**READ THE LABEL**

Use products approved under the Agricultural Chemicals Approval Scheme. Approval is indicated on the container by the mark shown here. A list of *Approved Products for Farmers and Growers* is published in February of each year and is obtainable as a priced publication from booksellers or from HMSO, PO Box 569, London SE1 9NH. This leaflet should be used in conjunction with the list.



### Acknowledgement

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