FRUIT COOL STORAGE SYMPOSIUM

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Organized by

The Department of Agriculture and the Orchardists and Fruit Cool Stores Association

DEPARTMENT OF AGRICULTURE - VICTORIA

FRUIT COOL STORAGE SYMPOSIUM

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PICKING MATURITY IN RELATION TO FRUIT QUALITY, STORAGE LIFE AND SUSCEPTIBILITY TO STORAGE DISORDERS

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Picking maturity is related to -

(a) quality of fruit after storage

(b) length of storage life

(c) susceptibility to storage disorders

For each variety of apple and pear there is an optimum picking period covering about a fortnight (slightly longer with late maturing varieties). When picked over that period the fruit has the highest eating quality after storage, it has the longest storage life and, most fortunately, also remains relatively free from the common disorders afflicting apples and pears in storage.

PICKING MATURITY IN RELATION TO FRUIT QUALITY IN STORAGE

Fruit picked before the optimum is not sufficiently developed. It lacks flavour and is poor in texture. Very early picked fruit will shrivel in storage. When picked after the optimum the fruit is overmature. It quickly loses its flavour in storage and goes mealy.

PICKING MATURITY IN RELATION TO LENGTH OF STORAGE LIFE

Longest storage life is obtained with apples and pears picked at the optimum picking maturity; the further removed from the optimum either before or after, the shorter the storage life. With fruit picked after the optimum there is quite a dramatic reduction in storage life. Fruit picked after the optimum has a much shorter storage life than fruit picked before the optimum.

PICKING MATURITY IN RELATION TO SUSCEPTIBILITY TO STORAGE DISORDERS

Fruit picked before the optimum picking maturity is susceptible to the common disorder Superficial Scald, the earlier the pick the earlier does the disorder develop and the more severe in form.

Fruit picked at the optimum picking maturity remains almost free from scald in storage. Fruit picked after the optimum becomes liable to senescent breakdown, the later the pick the earlier does the disorder develop and the more severe its form.

With early and late picks the onset of disorders marks the end of storage life, i.e., scald in early picks and senescent breakdown in late picks. The picks made at the optimum picking maturity remain almost free from both scald and breakdown and end of life with such picks is marked by decline in quality to the stage where the fruit has lost its flavour. Because of the absence of disorders fruit picked at the optimum maturity is often held in storage for very long periods, and the limitations to length of storage life as judged by loss of quality is overlooked. In other words, fruit picked at the optimum maturity is often overstored, even though free from disorders.

STORAGE PROBLEMS OF STONE FRUITS.

Compared with the storage of apples and pears the storage of stone fruits is difficult, for

(a) Stone fruits have a much shorter storage life

(b) They are very subject to low-temperature disorders when stored at temperatures suitable for apples and pears.

(c) They are highly susceptible to invasion by rots, especially brown rot, either in storage or shortly after removal from storage.

Should brown rot be prevalent in the tree at the time of harvest, then a considerable proportion of the apparently sound fruit will be carrying a latent infection, and if cool stored, will develop brown rot either in cool storage or during marketing subsequent to cool storage. In other words it is futile to cool store soft fruits from trees infected with brown rot.

Peaches, apricots and most plum varieties, particularly the Japanese varieties, are highly susceptible to low-temperature disorders when stored at 32° or thereabouts. After about a fortnight's storage at 32°, such fruits become dry and mealy. With further storage at 32°, the flesh discolours brown around the stone and objectionable off-flavours develop.

Such disorders may be avoided by storage at 42°, at which relatively high storage temperature, storage life is limited to about 3-4 weeks. If stored beyond that period the fruit will fail to ripen after storage.

It has been found that susceptibility to low-temperature disorders is related to the maturity of the fruit when stored. If the maturity is sufficiently advanced the stone fruits may be stored at 32° without disorders developing and by storage at the low temperature, a much longer storage life is forthcoming.

If peaches are picked slightly immature (pressure about 16-18 lb. by standard penetrometer) and then held at a temperature of 60° - 65° until the pressure falls to about 6 lb. (time required about 2-3 days) the peaches so treated may be stored at 32° without disorders developing.

When so treated, Smith's Seedling Peach had a storage life of 4½ weeks and Catherine Anne had a storage life of six weeks, which period is sufficiently long to permit of export.

PRE-COOLING AND TRANSPORT OF STONE FRUITS

Stone fruits such as peaches and apricots thrive remarkably well in the warm irrigated northern areas. Fruit grown in such districts may be marketed in first class condition in Melbourne and Sydney markets provided they are "conditioned" and pre-cooled before transport.

The peaches and apricots should be picked slightly immature, then held at 65° for 2-3 days (until the juice and flavour develops). The fruits are then pre-cooled to a temperature of 38°-40°. After pre-cooling which would take at least a day, the fruit is packed in suitable containers and then transported to market per insulated transport. It is evident that the provision of suitable plant for conditioning and pre-cooling of soft fruits will become an essential part of the equipment of growers sending stone fruit to distant markets.

OPTIMUM PICKING DATES AND LENGTH OF STORAGE LIFE AS JUDGED BY LATEST RETENTION OF GOOD QUALITY FOR THE MAIN VARIETIES OF APPLES AND PEARS AS GROWN IN VICTORIA ARE SET OUT BELOW

Variety	Optimum Picking Period	End of Commercial Storage Life(Quality still good).
Apples, (Scoresby)		
Jonathan	2nd & 3rd weeks in March	End October (sizes $2\frac{5}{8}$" & less)
Delicious	Last week March - first week April	Mid-November
Stewart	3rd & 4th weeks in April	Mid-September (large sizes)
Rome	3rd & 4th weeks in April	Mid-September (large sizes)
Statesman	3rd & 4th weeks in April	Early December
Granny Smith	Last week April - first week May	Early December(oil wrapped)
Yates	2nd & 3rd weeks in May	Mid-December
Pears, (Goulburn Valley)		
Bosc	2nd & 3rd weeks, March	Early September
Packham	2nd & 3rd weeks, March	Early November
Cole	3rd & 4th weeks, March	Early October
Josephine	1st & 2nd weeks, April	Mid-October
Nelis	Last week March - first week April	Early October

An allowance of plus or minus one week should be made in those years when the season is late or early.

Where the trees are carrying a light crop, maturity is hastened (as shown by advancing ground colour) and the crop should be picked earlier.

If picking must extend beyond the optimum fortnight then start picking earlier rather than extend the picking later.

All pear varieties store longest at a storage temperature of 29°-31°. Jonathan apples may develop low temperature disorders if stored at "pear" temperatures. Jonathans store best at 36° until the end of April, at 34° during May and at 32° thereafter. Other apple varieties can be stored with the Jonathan or stored at 32°.

CONTROLLED ATMOSPHERE STORAGE

I.D. Peggie
Horticultural Research Officer

Controlled atmosphere (C.A.) storage is a refinement of normal cold storage practice, in which both the temperature and the atmosphere within the chamber are controlled. The simplest form of C.A. cold storage is by controlled ventilation, in which the natural respiration of the fruit uses up part of the oxygen in the chamber atmosphere (normally 21% oxygen) converting it to carbon dioxide. The levels to which the oxygen is reduced and the carbon dioxide built up is fairly critical, and is usually controlled at 16% oxygen and 5% carbon dioxide by adjusting the ventilation of the chamber. Excessive build up of carbon dioxide can cause injury to the fruit.

A more difficult but slightly better technique is to allow the normal respiration of the fruit to use up most of the oxygen, and then the extra carbon dioxide produced is absorbed by chemical "scrubbers". Various modified atmospheres have been tested, and one generally giving the best results being 5% oxygen and 2% carbon dioxide. The term gas storage which might convey the idea of adding gas to the chamber is not now used.

C.A. storage works in much the same way as cold storage by reducing the rate of metabolism of the fruit, that is the rate at which the fruit lives. Just as lowering the temperature reduces this rate, so the lowering of the oxygen content of the chamber atmosphere also reduces it. Used in conjunction with cold storage C.A. by controlled ventilation can extend the storage life of apples and pears by about 25%. This can be most useful, particularly with late keeping varieties such as Granny Smith apples, and with large crops of a fruit with short storage life such as W.B.C. pears. Fruit subject to low temperature disorders must be stored at temperatures high enough to avoid fruit injury, but in so doing the storage life is reduced. In America and England varieties such as MacIntosh and Cox's Orange Pippin are held under C.A. storage which gives a useful life to the variety even at 38°F.

Another advantage of C.A. storage is the improved quality in Yates and Democrat which lose their woodiness and become good dessert varieties. Better retention of crispness and flavour in all varieties is usually noticeable under C.A. storage.

The disadvantages attached to C.A. storage are mainly in the extra costs involved in making the chamber gas tight, and in providing the apparatus necessary to make the CO_2 and oxygen readings - which are usually done several times each week. If low oxygen atmospheres are used, scrubbing equipment must be provided to remove the carbon dioxide, and daily attention must be given to the gas readings and the operation of the scrubbers. The chamber must be sealed as soon as it is filled and kept locked until the fruit is required late in the season. This limits the use of C.A. Storage to stores which have a number of cool rooms.

One problem encountered with C.A. storage has been the higher incidence of some storage disorders. However, attention to correct picking maturity, the use of chemically impregnated wraps, and the development of suitable storage temperatures and atmosphere concentrations have largely overcome this problem.

THE STORAGE OF CITRUS

I. D. Peggie
Horticultural Research Officer

There is normally little call for the storage of citrus in Victoria as oranges and lemons are available off the tree over most of the year. However glut periods do occur and there are other times when only small quantities are available or the fruit is of poor quality.

Navel oranges come in about May and are available for three or four months, but if there is a very heavy crop it is sometimes desired to hold a portion of the crop for later marketing. The Valencias follow immediately, starting in September and in late districts hold on until February. Attempts to carry the crop through until the Navels come in have not been highly successful, as the Valencias regreen and become dry and granular, with little orange flavour.

With lemons, the peak crop comes in the late winter-early spring, when sales are fairly slow, but in January the demand is much greater, supplies are scarce and so prices are high. Some growers have tried to hold part of their main crop in cool storage in order to catch these high prices but usually the holding period required is beyond the limit of the storage life of lemons. However, by regular marketing out of store during the late spring and early summer months and replacing the fruit sold with the small summer crop coming on it is possible to continue marketing lemons up till Christmas and still have fruit available for the January trade.

The advantage of having a store for lemons is that they may be "conditioned" before sale. In storage the thickness of the skin is reduced and most of the rag breaks down so that the lemon becomes a bag of juice. As lemons are bought mainly for their juice, it is likely that storage to "condition" them will eventually be as common here as it is in America.

The maturity of the fruit for storage is not as critical as with apples or pears, but for storage purposes the fruit must not be left too long on the tree or its storage life is reduced. Valencias must be picked before there is any sign of granulation, whilst lemons are usually picked in the silver green stage. Only sound fruit, free of any visible rot infections or skin injuries such as cuts or frost damage should be stored. Dipping in fungicidal solutions such as sodium orthophenylphenate can reduce the development of blue mould, whilst wrapping in diphenyl wraps, although more costly, is even more effective. Waxing the fruit will reduce the amount of shrivelling which takes place during storage.

The recommended storage temperatures for the various citrus fruits and the maximum storage life which might be expected are shown in the following table.

Oranges	$40-45^{o}$	3 months (early picked) to 1 month (late picked)
Lemons	45^{o}	3 months
Grapefruit	55^{o}	3 months

COMMODITY TREATMENTS

I.D. Peggie
Horticultural Research Officer

The development of commodity treatments has been undertaken by Government authorities to overcome quarantine restrictions raised by various countries against the importation of Australian fruit. These restrictions are aimed at preventing the introduction of various pests or diseases which do not already exist in those countries.

To satisfy an importing country that our fruit can be safely admitted, we must guarantee that either the pests they are concerned about do not exist in Australia, or else we have so sterilized the fruit that no live pest could be present in any consignment of fruit.

One of the insect pests which affects our fruit exports is the Queensland Fruit Fly. Fruit Fly is a major problem in soft fruits and apples, and because it infests citrus to a small extent, allowing it to breed through the year, it is greatly feared by many countries. For this reason, New Zealand authorities will not accept oranges from any district in which Queensland Fruit Fly occurrs unless it is given a satisfactory sterilization treatment.

To meet these requirements the Technical Committee on Fruit Fly Sterilization Investigations in Citrus developed a cold storage treatment in which the oranges are cooled and held for 14 days at a fruit temperature of 31°F. This treatment was accepted by New Zealand and allowed oranges from Mildura to be exported during the period in which Fruit Fly occurred in the Mildura district. Because of the time and cost involved, an alternative treatment using a two hour fumigation period with Ethylene dibromide has been developed. This treatment is already accepted by some countries and will eventually supersede cold sterilization for oranges. The fumigation of grapefruit, mandarins and lemons against fruit fly is also being tested.

A treatment for pears against Fruit Fly is required before an export trade to U.S.A. can be developed. As pears can readily stand the 31° temperature treatment, it is planned to use the cold sterilization method.

Similar sterilization work is planned to meet importing countries' objections to other pests that we have. Japan will not accept apples from countries having codling moth, but an effective fumigation treatment may well allow our apples on to this growing market. Preliminary investigations have started on this problem, and work will be commenced as soon as possible into sterilization methods for use against other pests such as San Jose scale and European Red Mite.

THE CONTROLLED RIPENING OF FRUIT

G.B. Tindale - Cool Storage Research Officer

Most temperate fruits ripen to perfection only over a narrow range of temperatures, i.e. between 60° and 70°.

It is not generally recognized that the soft fruits such as peaches, apricots and plums and also pears and tomatoes when picked slightly immature and then held at a temperature of 65° plus or minus 5°, will within a few days ripen to a degree of perfection seldom attained when left to ripen on the tree. When so treated these fruits will ripen firm ripe but "full of juice" coupled with excellent flavour.

In the summer months, when the soft fruits ripen, atmospheric temperatures are frequently in the 80°'s or even 90°'s. At such high temperatures the above fruits ripen quickly, but they ripen mushy ripe and are virtually devoid of flavour.

When soft fruits are allowed to ripen on the tree, they ripen very unevenly. Not only do the more exposed fruits ripen days ahead of the less exposed fruit, but the exposed side of individual fruits will often be fully ripe whilst the sheltered side is still hard and green.

By picking soft fruit slightly immature and then holding them at 65° they will not only ripen uniformly, but individual fruits will ripen evenly.

If tomatoes are picked when showing the first sign of pink, and then held at 65° they will gradually turn deep red and develop the richest tomato flavour and in particular they will ripen firm ripe.

Tomatoes picked slightly pink will turn red when held at any temperature between 45° and 90°, the higher the temperature the quicker will they turn red. However, at ripening temperatures below 55° or above 75°, tomato flavour does not develop fully. Indeed at temperatures about 90° tomatoes develop off-flavours coupled with a yellowing of the flesh, the disorder being known as "Boiling".

Pears seldom ripen with good quality if left to ripen on the tree. For each pear variety there is an optimum picking period of about a fortnight, and when picked over that period, and then placed in cool storage, they will, on removal from cool storage, ripen to perfection when held at 65°, provided the period in cool storage does not exceed the storage life of the variety. All the W.B.C. pears used for canning are controlled ripened in this manner.

At the optimum picking maturity pears are still hard and green. Over the late autumn, winter and early spring months, prevailing atmospheric temperatures in Victoria are too low for pears ex. cool storage to ripen properly and hence the local demand for pears at that time of the year falls away to a very low level.

By controlled ripening at 65° after cool storage, pears of excellent eating quality would be available ex.cool store most of the year. Some pear growers are now adopting this practice and are building up quite a good trade.

To control ripen fruit at 65° an insulated room is required equipped with refrigeration to reduce temperatures in summer and automatic heaters to warm the fruit in winter.

By providing a second insulated chamber the refrigeration equipment could be used for cooling the fruit to about 40°, when once the desired degree of ripening has been reached. When pre-cooled the fruit can be held if needs be for a few days to cater for week-end trade. If control ripened and pre-cooled fruit is sent to market in insulated trucks, the fruit will reach the market, even if hundreds of miles away, in perfect condition.

THE EFFECT OF ORCHARD PRACTICES ON FRUIT COOL STORAGE

by R.A. Mullett, Senior Horticultural Research Officer

The factors under the heading of orchard practices include the use of fertilizers, hormone sprays, cultivation, irrigation and pest and disease control. All of these factors are, to a large extent, under the control of the fruitgrower, but definite information on the effect of these practices on the storage quality of his fruit is either unknown or at least fragmentary.

In general, I think the position may be summarised by saying that most of these practices have their effect, if any, on the time of maturity of the fruit and in this way can affect the subsequent storage quality of the crop. It is clear that growers have not realised the importance of this factor and the way in which it may be altered by management practices, although the importance of maturity itself is realised - and has been emphasised already in this symposium.

Fertilizers

Nitrogen is the most important nutrient which may affect storage quality. There is considerable evidence that heavy dressings of nitrogenous fertilizer may delay maturity. This may not in itself be a factor in affecting storage life if the fruit is harvested at the correct stage of maturity, but as nitrogen also tends to reduce the amount of red colour on red apples growers tend to leave the fruit on the tree a little longer to get better colour, resulting in over maturity and shortened storage life. Nitrogen has also been shown to increase the amount of breakdown and rotting in storage. Victorian work by Baxter several years ago demonstrated that ammonium sulphate dressings of 2 lb. per tree did not affect storage life. There is some evidence that application of potash may increase storage life.

Hormone Sprays

The control of the crop is made considerably easier by the use of growth regulator sprays, commencing at blossom thinning and finishing with pre-harvest drop control. The use of this material has been blamed on a number of occasions for affecting storage life of apples and pears but officers of the Department have demonstrated quite conclusively that, while these materials affect the rate of maturity, there is no effect on storage life if the fruit is harvested at the correct stage of maturity for the variety.

Cultivation

Here the evidence is very limited. Some English work suggests that the use of a sward reduces storage disorders but this may be due to the reduction in nitrogen by the permanent cover. Soil management practices are a combination of effects of cultivation or grass cover, the use of fertilizers, irrigation and other factors so it is difficult to suggest that any one management system may affect storage life in a particular way.

Irrigation

For years growers have thought that irrigation adversly affected storage quality of their fruit. In a recent series of experiments Departmental Officers showed clearly that the effect of supplementary irrigation in Southern Victoria was to hasten the maturity of the fruit (apples in this case). It is possible therefore that growers who are not experienced in the use of irrigation may delay harvesting, not realising the hastening effect of the irrigation and this would give a false idea of the effect of irrigation on storage quality.

Pest Control

This topic is best covered by officers of the Biology Branch, but again there is little definite information on the effect of the many chemicals used today for pest and disease control, on the subsequent storage life of the fruit. Recently reported German work has indicated that some fungicides may promote ripening of some apple varieties.

THE PROBLEMS INVOLVED IN PLANNING AN ORCHARD COOL STORE

by J.W. Petty

During the last nine years I have had the experience of building two cool stores - one in Doncaster in 1954 and the other at Merricks North in 1962.

In relating those experiences and discussing the problems involved in planning an orchard cool store I intend to attempt to describe the main points which should be considered, in very general terms.

My experience suggests that the details and technical know how of these main points should best be left to the specialists, such as the men you are hearing at this symposium.

The cool store at Doncaster was built on stumps, a timber floor and frame, with fibro-cement sheet exterior lining, rockwool insulation throughout. The ceiling height was 12' from floor with ammonia coils hanging from the ceiling, giving me a stacking height of approx. 10', all fruit being stacked manually. The packing shed was attached to the cool room section 30' wide, wooden floor, fibro-cement external wall covering.

The experience I gained in building and operating that cool store, I believe, was of great assistance to me in planning the cool store which I built at Merricks North, last year.

The obvious disadvantages in the Doncaster one, I naturally tried to avoid in the new one. The things which I considered had been advantageous in the old store, I used in the new.

A great deal of thought should be given to planning an orchard cool store now, perhaps more than ever before.

Whereas a few years ago a grower would hold his fruit for the late markets and confidently expect a premium price for his fruit, today we don't enjoy the same benefits.

Therefore if a grower has to borrow money to erect his cool store, then a longer term loan is essential because of the lost advantage of premium prices referred to above.

Assuming that a grower could arrange a suitable financial scheme, the next step to consider is the size, type of building, and refrigeration.

The size of the cool rooms, of course, are related to his production. For the average grower two cool rooms seem to be the most practical, say, one for Jonathans and other varieties which cannot be stored at a low temperature and the other room for pears and apple varieties which stand lower temperatures. The size of his packing shed which is part of the total floor area, needs to be at least the equal of the floor area of the cool rooms, preferably larger. Remember, that possibly, the main reasons for planning a cool store are convenience and reducing production costs. Without ample packing shed space a grower loses both. In planning my cool store at Merricks North, I decided on two cool rooms totalling 2880 sq.ft. (each room 36' x 40') and a packing shed area of 5,000 sq.ft.

Because of higher labor costs, a grower must attempt to include bulk handling methods, with all its many benefits, in his planning. While this scheme adds considerably to the capital costs, it must be attempted to be incorporated to be able to gain full benefits.

Therefore the floor will be on ground level and of course concreted. In my case I used 3" water-proofed concrete sub-floor under my cool room area, vapour sealed 3" cork insulation then a reinforced 5" concrete top floor extending over the packing shed floor also.

For the building itself, I believe, a strong durable low cost structure is the most practical. I used a steel frame structure using galvanised iron exterior lining for both roof and walls.

This type of building can stand a lot of hard use, with low maintenance costs and a comparatively low capital cost.

As I had decided to use bulk handling and fork lift truck to stack the bulk bins I chose a ceiling height of 19', allowing a stacking height of 16'6", remembering it is cheaper to have higher walls than a larger floor and roof area.

Next thing to be considered is, in my opinion, the most important part of a cool store, the insulation. Not necessarily the type of insulation, as I believe all the insulating materials offered are of good quality, but make sure to have sufficient quantity.

A grower can be tempted to cut costs on this item. In my case many insulating firms suggested less of their material than I wanted to use which would result in a substantial saving in capital but higher running costs and poorer out-turn.

I decided on a double sided sisal paper for my vapour seal, then 6" of rockwool in the walls and 7½" of rockwool in the ceiling. Having taken great care with the vapour sealing and insulation, I believe, this has given me a very satisfactory job to cool store my apples and pears.

Next to plan is the refrigeration. The two popular types offered to growers are the forced draught, (or unit cooler) system, or the ceiling coils type commonly known as "direct expansion". As stated earlier, the technical details of each system are best left for more competent men at this symposium to discuss.

If I am to make comment as a grower I will sum up the two systems this way, after having heard other growers speak of their experiences with both systems.

The unit coolers appear better for quick cooling with cheaper capital costs, the "direct expansion" appears better for long storage with lower running costs.

Having had satisfactory results at Doncaster with "direct expansion", I again used it in my new store and although it has only been operating this season, I am very satisfied with the results to date. Whichever system is to be used, the same rule should apply as with insulation, i.e. it is better to have too much than too little. This way one can confidently expect, even temperatures, high humidity, low running costs and a good out-turn of his fruit.

Having decided these most important items, the next thing is the location.

Whether the cool store is to be placed well back from the road, near the centre of the orchard, or near the entrance to the property is strictly a matter for the individual. I selected a site near the entrance to my property, mainly because of the saving in maintenance of drive-ways to the cool store. Heavy road transports can do far more damage to one's drive-ways than the more constant traffic of tractors and trailers.

Finally, considering the position of the external cool room walls in relation to the sun is quite important if it is possible to do so.

I chose to put the packing shed to the north and west, thus giving my cool room walls almost complete protection from the sun. Although one can never prove the benefits of this it is reasonable to assume that without the direct sun on the walls there would be less heat transfer and therefore lower running costs. Having just experienced the problem of planning and building a fruit cool store, and having had sufficient time to assess the results, I am satisfied that this planning has given me - a low cost durable building in which I can use bulk handling, a packing shed large enough to give me efficiency and economy in handling, and with adequate insulation and refrigeration a cool store which gives a good out-turn of fruit with a low running cost for a capital expenditure of approximately £1 per case capacity.

PROBLEMS OF PACKAGES AND PACKING IN COOL STORAGE AND EXPORT

by E.G.Hall (C.S.I.R.O.)

SUMMARY

The life of fruit after harvest is governed by temperature and a degree/day approach is useful. In a cool store or a ship there is a direct relation between the rate of cooling and the equilibrium fruit temperature. Cooling can only be done by moving cold air.

Problems of containers involve physical protection of the fruit, cooling, container costs, ease and costs of handling. Bulk bins, cartons, modified wooden boxes and pallet units are considered primarily in relation to stowage and cooling in both local storage and export.

Provision of air gaps around every container and venting of bins are necessary for good cooling. Bulged boxes in a stack provide their own air gaps but flat-sided cartons need special treatment - open stowage in cool stores and vertical dunnage in ships. When freely exposed cartons cool as fast as wrapped and packed wooden boxes and bottom venting of bins can give even faster cooling.

Changes in packaging affect disorders. Apple scald is a problem in bins and cartons as the fruit is not normally wrapped. Treatment with diphenylamine or ethoxyquin is effective. Pears in lined bins may ripen faster and develop more mould and breakdown because of poorer cooling and higher humidities. Higher humidities increase breakdown in apples.

Proper use of polythene bag liners can increase storage life but reduced ventilation and near saturated atmospheres in them may increase scald and breakdown.

Because of changes in packaging and the increasing importance of ensuring improved condition at discharge experimental shipments of apples and pears are being carried out. Already these have resulted in the adoption of lower carrying temperatures. The importance of fruit temperature at loading has been emphasized by studies of cooling and fruit temperatures in ships. It is urged that the maximum allowable loading temperature for all pears be reduced to 40°F. Shipboard studies will continue with special attention to the handling and cooling of pallet units of cartons and boxes.

PACKING HOUSE EQUIPMENT

W.H. Harris - Senior Fruit Packing Instructor

Bulk Handling

In fruit harvesting there is increasing use of bulk bins. In the citrus industry bulk handling was introduced more rapidly than in the pome fruits areas. The reason for this is that the packing houses supply the bulk bins which have saved the grower this capital outlay. There are two types used, the Plant Handling Equipment bin of 18 case capacity which costs approximately £11 and the Showell bin with a capacity of 30 to 80 cases and costing £32 to £54.

The Goulburn Valley and many southern fruit growers have practically standardized the radiata pine bin of 20-case capacity costing approximately £5. The outside measurements of this bin including the built in pallett are 47" x 47" x 29¼". The height of this bin varies according to the height of individual cool stores.

The citrus industry use the gate type exits. These bins are placed on an inclined stand and when the door is opened the fruit simply rolls out on to the grader hopper. Growers of pome fruits generally use bins which have no doors and are therefore much cheaper to buy and need less maintenance. This bin is emptied by placing it with the fork lift on a specially constructed stand which fits under a sponge rubber padded lid By means of an electric or hydraulic tipper the bin is tipped onto its side so that the fruit falls against the lid. In the special lid is constructed an emptying door, the opening of which is controlled to regulate the flow of fruit passing onto the sizing machine.

Taking all factors into consideration this method is the cheapest to operate and maintain and in general terms the most efficient apart from the system of tipping into water.

Fruit Sizing Machines

Like any other equipment growers and packing houses select what they consider most suitable to their individual needs, but often after installing a grader they find it will not efficiently size all shapes of fruit.

The North West Apple Sizer

One of these machines is installed in the Granite Belt Cool Stores in Queensland. The bulk bins are emptied into water tanks and the fruit is simply carried onto the sizing section instead of running or rolling, but in keeping with modern U.S.A. trends to group size this machine is not intended to size as accurately as I think is required in Australia.

The price is £12,500 and its capacity 2,500 cases per day.

The Electronic Fruit Sizer

This is a Queensland manufactured machine which sells at approximately £1,400 and has a capacity of ~~300~~ 600 cases per day.

The large fruit is removed from the belt before the small sizes by means of an electric device which is operated by a micro switch and when fruit of the correct size releases the switch a rubber covered spindle simply pushes the fruit off the roller.

The Ansa Fruit Sizing Machine

This machine is a New Zealand patent which is now manufactured in Australia and like the electronic type removes the large fruits first. The fact that large fruit is removed first is possibly a good selling point but we must realise that the greatest portion of the fruit in any machine is sized in the middle of the sizing section, and therefore has no very great advantage. This machine does not size any more accurately than other sizers.

Belt and Roller Types

There are many of this type of sizing machines available and some doing a very much better job than others. This type of machine is known in the trade as the conventional type fruit sizing machine and taking all things into consideration including price, it is in my opinion not only the most used but the most suitable providing it is constructed with a wide sizing belt and friction driven independent section rubber rollers which are set at a slight angle across the belt. For some kinds and varieties of both pome and citrus fruits it is an advantage to size with a free roller but with others it is recommended to be driven. The adjustments can be made simply and quickly. From official tests carried out at the Company's request some few years ago this machine gave a sizing accuracy of some 90% using flat, round and conical shaped apples.

The price is approximately £1,400 and its capacity 1,000 cases per day.

Fruit Cases and Liners

There is nothing new in the various types of fruit cases used in Victoria, but we may be approaching the stage when it could be considered necessary to have a look into each case and the packing methods of the fruits which are packed into them. For instance what we are up against at present is bruising in the Australian apple box with apples, and abrasion with pears in the long bushel case and distortion of citrus fruit in the Australian dump case. It could well be that timber thicknesses should be looked at and cases being packed with too great a bulge. If it is desired that fruit is packed so high in the cases then should we be using a special bulge type case such as the standard apple box which is used in other States for practically all fruits.

From tests carried out last year with fruit case liners for pears and apples we are hopeful that some worthwhile contribution may be made in the near future.

For further trials which are to be undertaken next fruit season we will be using a new improved type pillowpatch pad as well as a suggested new corrugated fibre board pad and the plain waxed heavy paper liner which gave such good results last year.

There is no doubt from a bruising point of view fibre cases are an improvement over our present wooden cases but as bruising is only one of the many factors associated with the marketing of fruit, its ultimate acceptance is a matter for the industry. For instance, at present there is a price advantage to be gained in the Brisbane market and an apparent price disadvantage in the Melbourne and Sydney markets for fibreboard containers.

REFRIGERATION OF FRUIT (REVIEW)

by G.M. Rostos A.M.I.E. Aust. Consulting Engineer

A. PHYSICAL CONDITION

Fresh fruits are alive and remain so during storage and marketing. They respire using up stored substances, chiefly sugars, and oxygen from the air and produce heat and carbon dioxide

The environment in which they live after harvest influences the rate of respiration and the formation of other products in their life cycle.

This is the first factor in deterioration. Another important one is spoilage by micro-organisms, both depending greatly on temperature. Typically the rate of deterioration at 30°F is doubled at 37°F and is 8 to 10 times as great at 68°F - and this is why it pays to cool store fruit commercially. It is also worth noting that with some fruit storing at 30°F compared with 32°F can increase storage life by 20 to 25 per cent. This is of great importance in the long storage of fruits which keep well at freezing point e.g. pears. Dependable uniformity to within 2 °F permits storage 1°F above freezing point whilst a 4°F range would permit only 2°F above. Some fruits develop disorders at a low temperature well above their freezing point and present the same problem at that level.

The third important factor in deterioration is dessication. This is related strictly to the temperature and relative humidity in the immediate enviornment of the fruit. At, say, 32°F and 90 R.H. the rate of dessication is about the same as at 50°F and 90 R.H. Or at 32°F and 85% R.H. the rate would be about 1½ times greater. Respiration and hence deterioration can also be influenced by changing the composition of the atmosphere.

Some fruits, certain apple varieties in particular can be cool stored much longer if concentration of oxygen is reduced to 2 or 3% or the concentration of carbon dioxide increased to ~~[illegible]~~. 5%

B. DESIGN CONSIDERATIONS

1. Requirements These have to be set by the intending user.

Varieties of Fruit. This may be readily stated for a particular orchard. However, for a collective store the possibility of varieties from other orchards needs to be considered.

Length and purpose of Storage - It is to be determined whether all, or, sections of the establishment will predominantly handle fruit for -

(a) Long storage, for late marketing of first grade fruit.
(b) Pre-cooling for road or marine transport.
(c) Pre-cooling and/or ripening for canning.
(d) Short term general storage.

Maximum Daily Intake This requires the most careful consideration, not only the total daily intake but the size of batches, times of arrivals, and distribution into various chambers is of importance.

Larger cooling surfaces and air circulation is needed if chambers are filled in succession rather than distributing the fruit in various chambers.

Total Storage Capacity - This is a basic decision - entirely the user's

Size of Individual Rooms - There is no recognised system of thinking to determine, the shape and area of rooms. In general large rooms are favoured for fork lift traffic - but wide ones require costly roof trusses. Hence 30 - 40 ft width and lengths up to 100" seem to be favoured in large pre-cooling stores. This is also sound for the use of heavy cooling coils or forced draught cooling units without ducts.

On the other hand U.S.A. designers favour wide spans perhaps because they use more frequently the ducted air distribution system. The height of a cool room is readily determined from the fork truck lifting capacity. It comes out usually to 17' 0" plus clearance for coils or air flow.

Type and Size of Containers - This is vital information as it affects cooling rates and temperature uniformity. Standardisation viz. one or at least a small number of types for bins, pallets, boxes and cartons, could put the design for cooling and storage of large stacks of fruit on a much firmer basis.

2. Storage Conditions

These need to be considered in consultation with specialists, available usually from the State Departments of Agriculture.

Cooling Rates - The effects of delay before storage, slow removal of "top heat", and slow cooling close to storage temperature need to be appraised in terms of commercial gains for fruit which are sensitive in this respect. This problem is often made light. However, comparing prices for equipment to cool in 24 hours versus 48 hours will show the merits of deliberation.

Weight Loss - The control of weight loss is perhaps the most contraversial problem - as it affects the selection of cooling system and other design details. There is still no sure guide as to what extent dessication can be retarded at any particular storage temperature without introducing mould problems and whether proper humidity control with artificial humidification is worth while. Dessication during the initial cooling period can be quite high and could be reduced economically only by artificial humidification.

The merits of hydro cooling in this respect seem worth noting.

Storage Temperature - Prescriptions for this are usually readily available. However, the effects of a small departure from the recommended temperature are not so well known. It is quite important that the fruit temperature rather than air temperature be prescribed, as some cooling systems establish a closer approach of air to fruit temperature than others.

Controlled Atmosphere - It has to be settled whether a chamber is likely to be ever used for controlled atmosphere storage. If so it is worth while providing a gas proof, not only water vapour proof seal on the warm surface of the insulant.

3. Design of Building

Immediate and future development. Tree planting, possibility or orchard acquisitions may be a guide for this. However, in general it is sufficient to merely leave space for extension - rather than overdimensioning the store.

Vehicle Traffic and Materials Handling. This problem has seldom been given the attention it deserves. In large stores the saving through scientific design of handling can be substantial.

Arrangement of Chambers - This is closely linked with the traffic problem, the layout of grading machines and case store. The success of one or two orchardists to plan his floor should not be regarded as a proof that this is a task for the average orchardist.

Building construction - Local materials, facilities of building contractors, the method of insulation may govern the choice of the type of construction. Recent trends favour light steel frame with fluted or corrugated galvanised sheet cladding for orchard sheds and the insulated chambers established within the shed partly by insulating walls of the shed and partly by erecting timber stud frames with insulation.

Orientation anf protection from Sun. - It is generally recognised that the external walls of the cool store should if possible face South or East, the grading shed be adjacent to the West wall - for best thermal protection. Open air space above the insulated ceiling is preferable where it can be established economically - but a little extra insulation perhaps one layer of aluminium sisal with air gap on both sides may be sufficient if the roof itself is insulated. This latter method proved economical with gable and skillion roofs in stores with forced draught cooling units.

Thermal Insulation. - This is a task for contractors with specialised experience, though many orchardists have been successful in doing it themselves.

The systems and materials used are many and varied. Insulation of shed walls, internal stud walls and ceilings with mineral wool batts is one of the most common methods. The thickness of insulant varies between 4" and 6". Double sided sisalation is used for vapour seal almost everywhere. Slabs of compressed straw (Solomit), in 2 or 3 2" layers is also an economical insulant. The ceiling is usually lined with hardboard, or asbestous cement, the walls are not always lined, mineral wool batts are held by wire netting and Solomit is left bare, sometimes spray painted. In a recently built store V-crimp roofing sheets were used for internal lining. Reflective insulation e.g. 3 to 4 layers of double sided sisalation, with air gap in between is a further economical system of insulation for walls and ceilings and aluminium alloy sheets applied in similar manner, with heavier gauge lining sheets of the same material are also available.

Rigid slab insulants are more frequently used on masonry buildings, small 3' x 1" slabs such as cork or onazote in particular. Others such as foamed polystyrene and polyurethene sheets come in large slabs up to 6' x 20' and can be well adapted to any type of building.

On masonry surfaces the vapour seal is formed by bituminous emulsions serving also as adhesive. They may be spirit based as Laminex P 50, or water based as Flintkote, Laykold, or Emastak.

The thickness of cork insulation is usually 4", polystyrene 3" or 4" and polyurethene 2" to 4". In pre-cooling stores in southern parts of the State or - Tasmania a little less can be satisfactory.

Panels of rigid foam insulant with lining board bonded to one or both surfaces, are also available. They may be used for insulating stud frames or ceiling as wall as masonry well.

Prefabricated cold stores, built entirely of panels without structural frames, are also available. One type has oregon framed panels with mineral wool insulation, others have hardboard or metal, polystyrene insulation and adhesive bonded lining on both sides, forming a structural skin reinforcement. A very successful type of prefabricated cool room consists of polystyrene slabs with bonded hardboard skin and polyester finish, without timber frame.

Loose fill insulants, granulated mineral wool, and buzzerchip are still used quite widely in studframe construction and on ceilings. Buzzerchips are available very cheaply in some areas.

Floors - With fork lift handling almost universally adopted, all new stores are built on the ground. The floor may not be insulated if the area is large and the water table is low. In this case only a vapour seal is applied under the concrete floor and a 2' or 3' strip at the perimeter is insulated either with vertical slabs as a continuation of the wall insulation, or, with horizontal ones under the floor.

However, in most of the stores floor insulation is desirable. The cost of cooling the large mass of earth is quite large if done each year.

Slab insulant, in particular cork or Onazote or Solomite which have relatively high compressive strength do not require such a strong working floor as do polystyrene or polyurethene. However, the difference is not always important. Reinforced working floors are usually 5" to 6" thick and sub floor 3" to 5" according to the nature of the sub-soil.

Doors - Sliding doors are almost universally used for fruit cool stores today. For fork lift trucks 6' x 9' is a suitable size. The panels are made generally of 4" oregon frame with polystyrene insulation. Ball type sliding tracks and lift-up type closers with 4 catches and drop action and single lever operation have been used widely up to date. More recently wedge type closing and wheel-on-rail type tracks, which drop into terminal notches in the rail, are becoming available.

Automatic electro-pneumatic closing mechanism is used in a few stores. Air curtains are being installed in more and more stores.

4. The Refrigeration System

Estimation of Cooling Load - Information available on the specific heat of fruit respiration rates, thermal conductivity of insulants and construction materials, motor ratings etc. permit the accurate calculation of steady heat flow. However, its extremely difficult to estimate the rate at which the fruit releases heat at the various stages of cooling. This uncertainty must be covered by 30 to 50% allowance for high initial cooling demand - if the fastest possible cooling is important. This is particularly so in a store where the daily intake can be large in relation to the total holding.

Mode of Cooling - Cooling in the storage chamber by air circulation is the general mode of pre-cooling and holding storage temperature. However, hydro-cooling, i.e. cooling by spraying with, or submerging in chilled water prior to storage or transport is used in some other countries and may be adopted here. Natural circulation from bare coil grids suspended from the ceiling has been the most widely used system, in Victoria particularly, for the last 30 years or so. Frost is allowed to accumulate on the coils during the storage season. Temperature control and uniformity of cooling are most satisfactory, the weightloss from the fruit is small and operation is cheap.

For long storage this system is likely to remain - however for pre-cooling or general storage forced air circulation from compact cooling batteries is more suitable. A well designed forced draft system can be just as light on drawing moisture from the fruit as a natural circulation one - but it will always consume slightly more power.

Ducted air distribution systems for one or more chambers from a single cooling battery has seldom been used in Australia in recent years - though it can be most suitable and economical for certain type of fruit cooling. It should not be omitted from planning considerations.

The Refrigeration Plant

"Direct expansion" viz. air cooling by evaporating a refrigerant in the pipes, is the means of heat removal from the cool room in all fruit stores. Compressors are of the reciprocating type, in new plants multi-cylinder, V-block type. Evaporative condensers are used throughout natural circulation with older installation, forced circulation with new ones.

The flow of refrigerant is controlled by thermostatic expansion valves in small and medium size plants, by flooded, float operated system in many medium and large ones (over 50 tons of refrigeration). The largest plants have mostly "liquid re-circulation", (central flooding) system. The refrigerant is Freon or ~~Argon~~ Arcton in small and medium plants and ammonia in the medium and large ones.

Temperature Control

Many of the older large plants are still controlled by manual adjustments of isolating valves or expansion valves but automatic control is becoming universal. The economy and accuracy of holding the desired temperature level automatically by room thermostats and magnetic stop valves is quite superior.

For the refinement of temperature control and for operational economy the capacity of compressors may be controlled by back pressure operated suction valve lifters, or, stopping one or more of several compressors.

Uniformity of temperatures in time, viz. over a stop start cycle is satisfactory in fruit stores in general, owing to the "fly wheel" effect of the large mass of fruit. However, uniformity in space needs careful consideration. Ceiling coils are designed with overlapping and opposite feeding to ensure even cooling and forced air cooler are designed with ample air circulation and jet speed to maintain small increase in air temperature and air flow into every part of the room.

Humidity Control

Relative humidity is not controlled positively, i.e. a natural relative humidity establishes itself. However, the moisture extraction on the cooling surfaces which govern relative humidity, hence dessication of the fruit, is kept to the minimum by design. Reduction of the dry heat load i.e. efficient insulation of the chamber and small fan power (nil in case of natural circulation) are the primary measures. Large cooling surface and large air circulation are the secondary measures. As fan power and air circulation are opposing factors, striking a balance for optimal results is quite important.

Direct humidification by atomising sprays or by using "air washers" i.e. a shower of chilled water for air cooling is adopted in a few stores overseas - but not in Australia.