What is cold storage?
The protective storage of crops using a combination of low temperatures and high relative humidity to maintain stock viability and quality.

Cold storage
- Powerful crop management tool
- Reduces wastage
- Increases efficiency
- Allows a greater flexibility of supply
- Exploit effects of climate change

HDC Projects
- HNS 41: Stock plant management and preconditioning
- HNS 42: Pre- and post-rooting storage of softwood and hardwood cuttings
- HNS 43: Management opportunities in the budding nursery for planting liners and growing trees for containerisation
- HNS 62: Development of scheduling techniques for containerised bush roses for successional spring and summer sales
- HNS 83a: Roses: improving early establishment of bare root roses in containers using auxin root dips
- HNS 103a: Hardy herbaceous perennials: value of a screening protocol for factors that manipulate flowering
HDC PROJECTS

Hardy nursery stock
- HNS 109: Investigation into the cause(s) of stem canker/die-back in container grown Malus, Plums, Peaches, and ornamental Prunus
- HNS 113: The feasibility of using low temperature storage as a scheduling aid in nursery stock production
- HNS 140: Survey to determine current industry practice and future needs for the use of low temperature storage
- HNS 164: Improving basal breaking of field-grown roses using ethylene releasing agents

HDC PROJECTS

Protected crops
- PC 114: Osteospermum: extending the season of production and examination of environmental effects on quality
- PC 196: Bedding plants: the use of low temperature storage as a scheduling aid in bedding plant production (Autumn Pansy and Primrose crops)
- PC 256: An initial investigation into the potential for using sealed greenhouse technologies in the UK

Bulbs and outdoor flowers
- BOF 42: Narcissus: the handling of bulb stocks with basal rot

COLD STORE USES IN HNS 140
- Nursery management tool to hold and schedule stock for sales, transplanting or potting
- Storage of propagating material
- Improved accuracy of scheduling to meet customer requirements
- Increased flexibility to meet and maximize sales opportunities
- Greater opportunity to produce niche crops and compete with imports
- Improved efficiency in propagation, planting and despatch operations
- Improved hardiness of plants
- Reduced labour inputs for growth control – trimming and holding plants

HNS 140
- 40% participants used CS to over-winter bare-root nursery stock for sale/potting
- Used CS between November and April
- Target storage for limited summer use was 1-2°C and 80-100%RH
- 50% storing transplant material for plant when weather allowed/labour available incl. containerised roses, herbaceous perennials, fruit nursery stock and ornamentals trees
- Fine-rooted material suffered the most e.g. Fagus

Cold stores for PROPAGATION
- Seeds and cutting material
- Budwood and scion material
- Hardwood material especially for Cornus, Malus, Prunus, Platanus, Populus and Salix

Particularly useful in summer to keep large volumes of soft material fresh

A quick guide for those thinking of using a Cold Store
- Acquiring facilities
- Environmental control
- Energy management
- Construction
- Crop examples
- Lighting
- Temperature tips
- General storage considerations
Cold stores for PROPAGATION

Seed storage and treatment
- To break dormancy
- To maintain seed viability between harvesting and sowing – seed embryo is maintained in a quiescent state
- To initialise cold treatment year-round (3°C optimum level; 1-2°C reduces risk of seeds starting to germinate)

Seeds need to be mature and of good quality
Seeds with a high fat content don’t store well e.g. Abies

Store choice
- Domestic fridge OK for small seed lots
- Cold store required for large volumes

Cold stores for PRODUCTION SCHEDULING

Meeting market demands for continuity of supply

Bedding
- Short-term plug storage for spring/summer supply
- Less production space and labour required to hold plugs back and maintain quality vs. PGRs/reduced watering/liquid feeding/trimming
- Plugs only require a small space in cold store

Cold stores for PROPAGATION

Seeds: optimum storage conditions
A cold store needs to
- Immobilise certain essential enzymes
- Slow down respiration = slowing deterioration of stored food reserves
- Stabilise seed moisture content – fluctuations reduce viability; too much moisture increases risk of P&GD
- Control seed storage temperatures to maintain viability

Cold stores for CUTTING MATERIAL

- Storage of material prior to preparation and insertion e.g. trimmings from crops/stock plants
- Useful if labour not immediately available and during warm weather (removes field heat)
- Two hours at 1-3°C restores turgidity
- Used for soft and semi-ripe cuttings (spring/summer) from March to October
- Winter use: 1-5°C
- White bags; absorb less heat; damp them down inside before use

Benefits of COLD STORES

- Delay in flowering to meet demands of GCs and retailers – frequent small volumes through the season
- Chilling to initiate flowering – Hydrangea, Hebe and some herbaceous sp.
- Maintenance of bud/flower for longer (Azalea, Camellia; flower show material)
- Manipulation of glasshouse throughput using cold stored crops – can better cope with increased demand and extend the sales season
- Free up space in the winter for other plants to go under protection
- Early spring sales
- Maintain plant quality of crops loaded on trolleys waiting to be despatched – plants can be harder and more stress-tolerant
- Inducing and maintaining dormancy in mild winters

Careful checks required to prevent flower drop/damage

Limiting factors

- Knowledge and skill level of staff
- Over-reliance increases the risk of producing poor quality crops
- Having sufficient storage capacity for peak times
**Types of cold storage systems**

- Ambient cooling
- Direct refrigerative cooling
- Wet air cooling
- Jacketed cold stores

**Direct refrigerative cooling**

- Type of store usually available for renting
- Uses refrigeration and a fan which can create a dry atmosphere
- Moisture removal from store air is affected by temperature difference of store air moving through cooling system
- High temperatures = dry stores
- The larger the surface area of the cooling system, the bigger the temperature difference achievable.
- Large surface area increases capital costs
- Plant material wrapped in plastic film reduces water loss
- Can be used as a temporary holding for unwrapped nursery stock: overnight or up to two days max.
- Ideal as a short-term store

Typical operating temperatures are -2 to +5°C with 95-100% RH

**Ambient cooling**

- Ventilating a cold store using outside cold air during the winter
- 0-1°C mid-winter; <5°C November-late March
- Requires good insulation (to same standard as a refrigerated store if possible) and an efficient, well-controlled fan
- Temporary stores can be successful in mid-winter e.g. straw bales protected from rain and wind using plastic sheeting
- Fan: equivalent to 30 room volumes/hr; inlet/outlet vent air speed of 5mts/sec (to give 100pa pressure)
- Fan: shouldn’t raise air temp >0.5°C
- Install a differential thermostat: compares inside/outside temps and runs the fan for short periods avoiding a reduction in RH

**Wet air cooling**

- Air is cooled by direct contact with chilled water
- Moisture loss is minimal with this system
- Impossible to cool below freezing: ideal for frost-sensitive species
- Normal operation at around 1°C: some sp. don’t achieve total dormancy

Sodium carbonate can be used to reduce water freezing point but NOT standard anti-freeze products

Store air is drawn through and cooled in a heat exchanger (tower filled with honeycomb material to break flow of chilled water = max surface area of water is exposed to the air)

The heat from the crop is absorbed by cooling water

If some air not fully cooled (cross-flow systems) RH of discharge air can be reduced significantly which results in plant desiccation
**Ice Bank cooling**

Chilled water produced by ice bank
- Method: water tank + refrigeration plates onto which water freezes. Ice block produced creates 'bank' which is drawn upon when cooling load exceeds capacity of refrigeration plant.
- Allows compressor to run only during periods of cheap electricity tariff
- Other advantages: high RH, low temperatures and rapid cooling
- Other disadvantages: costs are higher than using sprayed coils and operating efficiency is lower

**Jacketed cold stores**

- Popular for long-term storage of seeds, cuttings, forestry transplants, nursery stock
- Plants separated from refrigeration system by waterproof walls

**Structure**
- Conventionally insulated outer shell and metal-walled inner shell – air from cooler is circulated in the space (jacket)
- RH maintained as two air spaces are kept separate
- Heat build-up from inside the store is removed by cold air in the jacket via a thermally conductive inner wall
- Air speed inside the store and temperature gradient across jacket is low, rate of heat transfer from store is also low
- To obtain maximum cooling: large wall surface area required and is achieved by circulating the air in the jacket completely around the store
- Not suitable for small cold stores

**Advantages**
- Maintenance of high RH levels (95%)
- Risk of dehydration of plant material is very low
- Slow movement of air reduces risk of fungal spores spreading through plants in the store

**Disadvantages**
- More expensive than similarly sized direct cooled store: additional inner shell + support structure but cost similar to wet air cold store
- Inner shell can suffer from uneven cooling and localized freezing if air distribution is poor e.g. if jacket becomes blocked by ice or insulation material becomes detached
- Problems with air distribution are difficult to mend; jacket is difficult to access
- Will not remove heat quickly:
  - unsuitable for storing material that requires cooling e.g. removal of field heat or for material producing heat by respiration

**Construction**

**Insulation materials**
- Compare insulation values; physical strength; ability to achieve a good airtightness; resistance to heat/moisture/pests
- Costs: calculated for total structure of the wall/ceiling and based on equivalent R values not necessarily equal insulation thickness
  e.g. Polystyrene slabs, foam, flexible quilt products

**Position of insulation**
- Good positioning avoids unnecessary heat gain and humidity loss. Thermal bridges are created through structural members in direct contact with both inside and outside air
- Avoid bridging by using insulation materials that isolates structural members. Position between outer cladding and sheathing sides or above roof purlins/below roof sheeting.
- Insulated floors must also be built from a sound base.
CONSTRUCTION

Maintaining structure and insulation

- Prevention of moisture getting into materials whilst maintaining RH is important
- Careful design can prevent moisture and dampness from rain, snow and crop moisture getting in
- Risk of water vapour migration as a result of temperature differences between outside and inside of cold store
- Minimise moisture movement by using a vapour barrier on the walls, sides and ceiling which remains continuous and unbroken throughout e.g. metal foil, polythene sheet and/or bitumen

CONSTRUCTION

Vapour checks (VC)

Reducing no. of doors/vent openings reduces risk of seals leaking

Position: on the ‘warm side’ of the insulation – this varies depending on the time of year

Two options

1. Install VC on both sides of the insulation (has to be vapour-proof to avoid trapping moisture in structure)
2. Install VC on the side of the insulation that is warmest for the longest period of time (allows other side to ‘breathe’ naturally)

CONSTRUCTION

Doors

- Can be a major source of heat ingress and moisture loss
- Insulate to same standard as store with same internal finish
- Install draught excluders e.g. flexible nylon brushes/synthetic rubber gaskets
- Make sure nursery staff keep doors shut as much as possible
- Doors should only be large enough for handling equipment and machinery to enter and leave CS
- Small personal doors ideal for staff monitoring and store management
- Make sure floors are properly insulated too

CONSTRUCTION

Temperature tips

- Important to avoid chilling injury plants vary in their sensitivity to cold
- Bare-root roses: 0°C

Optimum storage temperatures

<table>
<thead>
<tr>
<th>Plant</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garrya</td>
<td>1-4</td>
</tr>
<tr>
<td>Azalea</td>
<td>1-3</td>
</tr>
<tr>
<td>Amelanchier</td>
<td>1-2</td>
</tr>
<tr>
<td>Decandra</td>
<td>1-3</td>
</tr>
<tr>
<td>Erica Lusitanica</td>
<td>1-4</td>
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<tr>
<td>Hydrangea</td>
<td>1-3</td>
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<tr>
<td>Hamamelis</td>
<td>1-2</td>
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<tr>
<td>Hosta</td>
<td>1-3</td>
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<tr>
<td>Viburnum</td>
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<tr>
<td>Forsythia</td>
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<tr>
<td>Magnolia</td>
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<tr>
<td>Viburnum</td>
<td>1-2</td>
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<tr>
<td>Paeonia</td>
<td>1-2</td>
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<tr>
<td>Cypripedium</td>
<td>1-2</td>
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<tr>
<td>Philadelphus</td>
<td>1-2</td>
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<tr>
<td>Choisya</td>
<td>1-2</td>
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<tr>
<td>Japanese Acro</td>
<td>1-2</td>
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<tr>
<td>Paeonia</td>
<td>1-2</td>
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<tr>
<td>Tilia</td>
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<tr>
<td>Elaeagnus</td>
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<tr>
<td>Cytisus</td>
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<tr>
<td>Camellia</td>
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<tr>
<td>Ceanothus</td>
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<td>Viburnum</td>
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<tr>
<td>Corylops</td>
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<td>Laburnum</td>
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<td>Deutzia</td>
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<tr>
<td>Skimmia</td>
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<tr>
<td>Malus</td>
<td>1-2</td>
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<tr>
<td>Spiraea</td>
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<tr>
<td>Japanese Acer</td>
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<td>Viburnum</td>
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<tr>
<td>Pieris</td>
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<tr>
<td>Magnolia</td>
<td>1-2</td>
</tr>
<tr>
<td>Alpine rose</td>
<td>1-2</td>
</tr>
<tr>
<td>Magnolia</td>
<td>1-2</td>
</tr>
<tr>
<td>Persicaria</td>
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</tr>
<tr>
<td>Solanum</td>
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</tr>
</tbody>
</table>

Cold storage temperatures used in the UK (HNS 140)

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Plant</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General storage</td>
<td>Forsythia</td>
<td>1-2</td>
</tr>
<tr>
<td>Generation</td>
<td>Forsythia</td>
<td>1-2</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Forsythia</td>
<td>1-2</td>
</tr>
<tr>
<td>Market scheduling</td>
<td>Viburnum</td>
<td>1-2</td>
</tr>
<tr>
<td>Market scheduling</td>
<td>Viburnum</td>
<td>1-2</td>
</tr>
<tr>
<td>Production scheduling</td>
<td>Viburnum</td>
<td>1-2</td>
</tr>
<tr>
<td>Production scheduling</td>
<td>Forsythia</td>
<td>1-2</td>
</tr>
<tr>
<td>Production scheduling</td>
<td>Forsythia</td>
<td>1-2</td>
</tr>
<tr>
<td>Short-term storage for immediate sale early season</td>
<td>Viburnum</td>
<td>1-2</td>
</tr>
<tr>
<td>Long-term storage (VCS is April/Oct - VCS)</td>
<td>Viburnum</td>
<td>1-2</td>
</tr>
</tbody>
</table>

Note: Temperature (°C)
**Temperature tips**

- Store may need to run at a lower temperature to remove field heat
- Ambient stores: naturally cool air is drawn in via the ventilators = reduction in costs
- Accurate temperature control is vital in direct cooled and jacket stores
- Jacket CS: cool-down is slow – monitor jacket temperature not chamber temperature
- Wet air CS: won’t run below freezing
- Ice bank coolers: refrigeration is controlled by ice thickness sensor and on the sprayed coil by expansion valve setting (override sensor may be installed to detect large accumulations of ice on the coils)

**Example cooling programmes**

**Bare-root nursery stock for transplanting (stored above freezing)**
- Initially store at 3 to 4°C
- Lower temperature to 2°C by Nov/Dec
- Lower temperature further to 0.5°C by February

**Forestry Commission example**
- Sitka spruce and Japanese larch: 4°C until mid-December then 2°C (short-term); -2°C (long-term)

**Prop material**
- More susceptible to damage from low temperatures, duration of cold storage and desiccation
- Maintain temperature at or above 2-3°C to prevent frosting leaves
- Max. storage time dependent on plant species

**Production scheduling**
- -2°C and 2°C compromise between maintaining dormancy, preventing damage and inhibiting fungal growth

**Example cooling programmes**

**Bare-root nursery stock for transplanting (stored below freezing)**
- Once dormant, lift and store at 2-3°C until December
- Grade stock and gradually reduce temperature to 1°C
- Keep reducing temperature gradually to -3 to -4°C
- Defrost slowly by removing plants from store and spreading on floor of a shed out of direct sunlight
- Water 2/3 times throughout the day to achieve a gradual thaw
- Plant out

**Herbaceous perennials**
- Cooling can inhibit flowering e.g. Astilbe x arendsii (9 weeks @ 5°C)
- Cooling can promote flowering e.g. Catanache caerulea
- Optimum storage quality of HPs: late field harvest (Nov/Dec) with a critical soil temperature of 10°C for some species
- Other seasonal effects may also play a part i.e. day length, frost intensity, air temperature cycles

**Broadleaved trees**
- Effect of lifting date on Betula pendula and Quercus robur is similar to HPs
- If lifted too early e.g. mid-September, plant vitality is affected and can affect quality of cold storage
- For improved stress tolerance the critical temperature is 5°C (usually after mid-October)

**Seeds**
- For storage and stratification: put into sealed plastic bags, mixed with some growing media to avoid drying out at -6 to 2°C
- Knowledge of species tolerance important to prevent embryo damage and poor germination rates
- > 15°C is sometimes needed for seed germination post-storage
Temperature monitoring/record keeping

An essential part of good store management

- Most stores are thermostatically controlled, some with feed-back to office computer/mobile phone
- Monitor temperatures daily using probes/thermometers
- Place monitoring equipment throughout the store; easier to check for uneven cooling; ‘slug’ with plasticine or place in jars of water to get an average temperature
- Use a combination of mercury and digital thermometers. Do not rely on digital readouts alone
- Check bagged material; it can sometimes generate heat
- Keep records: date when material entered store; temperature; dates of any temperature changes; any problems that have occurred with the store/material; incidence of disease

Relative humidity (RH)

- Measure of the amount of water vapor in the air, usually expressed as Relative Humidity (RH)
- It compares max. amount of water vapor in the air to the amount of water the air could hold at the same temperature
- Humidity can give an indication of the evaporation/transpiration potential of plants
- Low humidity = desiccation of plants
- High humidity = risk of disease infection

In-store humidity levels depend on

- Air temperature difference across the refrigeration coil
- Humidity of the outside air
- Temperature of the outside air
- How much plant material is in the store
- The type of store being used

The more moisture held in the store = more energy to cool it down

Disease infection

- < 85% RH = less disease incidence
- Leaf wetness: can increase symptomless disease infections
- Air movement keeps disease levels low
- Temperature is also a factor; Botrytis remains active at 0°C
- Avoid storing plants susceptible to root rot (Pythium and Phytophthora) as cold damage can weaken their roots

Humidity monitoring and control

Options available include:

- Damping down
  - On bare-root nursery stock either at start of season or on a weekly basis
  - Mains water can be 4-10°C which increases CS temperatures
- Wrapping in plastic
  - Important for direct cooled stores
  - Other materials available incl. fleece-lined plastic trays for propagating material
- Plants stored in pots
  - Irrigate prior to storage; check regularly and water if required
  - Keep leaves dry and growing media moist (not wet)

Foggers

- To maintain humidity
  - Set to run on short bursts e.g. 2-3 mins every 15 mins
  - Difficult to set up correctly - can be unreliable if using an electronic sensor
- Reduced visibility can be a H&S issue

Misters

- Can have a limited effect
- Avoid droplets of water falling on plant material
- Avoid systems that use heat to evaporate water
Humidity monitoring and control

- Humidity equipment combined with the cooler
- Spray chillers + ice banks = high levels of humidity in store
- Moisture used as the heat transfer medium and temperature difference is small
- Operating at or below freezing is difficult

Types of lighting

1. General Lighting Service (GLS)
   - Glass envelope + tungsten filament + inert gas
   - Light output obtained by varying the power: the design and use of reflectors: by the use of transformers to adjust voltage e.g. 12V, 24V or 240V (halogen lamps)
   - Affected by voluntary phase-out of energy inefficient bulbs by Defra (30/12/2011)

2. High-intensity discharge lamps (or HIDs)
   - Very efficient – low thermal output and long life e.g. high-pressure sodium lamps
   - High light output – enables human eye to distinguish between colours
   - Light discharge = 150 lumens/watt
   - More suitable for larger stores
   - Disadvantage: time it takes to achieve full luminance from switch-on
   - Separate lighting circuit with fluorescent tubes recommended for doorways and walkways for quick illumination

Lighting

- Safe access in and around working area
- Lighting and light quality not important for plants being stored
- Controls need to be outside store to reduce heat gain
- Commonly used: sealed fluorescent light units or 250W high bay lighting

- Purpose – what is it to be used for?
- Capital costs and running costs
- Energy efficiency of equipment
- Fitting quality – waterproof, rustproof
- Layout – to allow good inspection (at least 150 lux) and conform with H&S

Types of lighting

3. Mercury vapour lamps
   - Low capital cost but use more electricity than HIDs

4. LEDs
   - Small semi-conductor (diode) which emits light when an electrical current is passed through it. Most of the energy is converted to light
   - Long lifetime, long durability, low maintenance, very efficient
   - Expensive to buy
     LED lifetime: 100,000 hours e.g. 27 yrs if left on for 10 hours/day!
     Compact fluorescent lamps: 50,000 hrs
     Incandescent bulbs: 5,000 hrs

Lighting controls

1. Manual switch on
   - Switch located close to doorways

2. Automatic lighting (PIR)
   - Easier when using forklifts
   - Lights only on when area occupied (plus time-delay)
   - Reduced energy use
   - Photocells also available: ensure lights only come on if light level is too low
**Ethylene**

- Stimulates fruit ripening and premature flower abscission
- Higher temperatures = increase in ethylene levels
- Levels not generally monitored in stores for nursery stock but can be affected if store also used for fruit and vegetables
- Old fruit stores: ethylene can be absorbed into fabric of store and can release over time
- Other sources: decaying plant material; exhaust fumes from LPG forklifts
- 5ppm concern; 2-3ppm long-term may cause injury to softer material
- Symptoms: foliage yellowing; contorted growth
- Can be an issue with rented cold stores – check history before use

**CS management**

*Do's*
- Reduce air temperature gradually to mimic nature
- Site temperature display outside store
- Choose a temperature that will suit the majority of species
- Collect prop material early in the morning to reduce field heat removal
- Stack pallets at least 10cm apart and allow 50cm vertical clearance (top of plants and bottom of next pallet) for free air circulation
- Monitor temperature daily at a number of points within the store
- Use a separate personnel door for stock inspections

*Don'ts*
- Open the door unless essential
- Overfill bags of propagation material – takes longer to remove heat and cuttings will deteriorate

**Location, design and layout**

*Locate*
- Near work areas to reduce handling time – removing material for orders; grading; cutting preparation and sticking
- Seed stores – locate near weighing room or seed cleaning/preparation areas

*Design*
- Leave plenty of room to work in and use forklifts (3.6m aisle to turn and stack cages)
- Avoid filling the aisle = H&S issues; inefficient handling
- Good working access from the outside – keep the area clean and in good condition for quicker forklift handling

**Energy efficiency**

Four basic measures
1. Using energy efficient equipment – lights, fans, cooling
2. Ensuring the store is well insulated and sealed
3. Good housekeeping and environmental control – don’t overfill the store
4. Regular equipment maintenance along with an annual service

- Accurate temperature control: if store is set 1°C lower than necessary, energy costs can increase 2-4%
- Position heat rejection components carefully – avoid installing near sources of heat and direct sunlight
- Ensure condenser has enough ventilation so rejected heat can dissipate easily
- Regular air-filarming to prevent ice build-up – most evaporators are fitted with auto-defrost
- Avoid storing plant material directly under evaporators which will impede air flow
- Use thermal clothing for staff to reduce energy costs

**Plant handling check list**

- Handle plant material with care to avoid physical damage and increasing risk of deterioration
- Remove bruised leaves and plants with damaged stems
- Don’t pack material too tightly
- Keep foliage dry
- Wrap plant material where appropriate
- Lift field-grown stock as late as possible to allow abscission as advanced as possible and material has had time to harden off
- Some nurseries point roots outwards on stillages to prevent damage of plant material
- Bags are tied to prevent excessive water entering root zone
- Make sure all material is well labelled using waterproof markers and labels
- Date the material when it enters the CS
- Larger stores: log location of each species/varieties to make handling easier
Acquiring a Cold Store

- Purpose-built: tailored to your requirements; needs to be cost-effective – how long would it be in use?
- Used or second-hand facilities: potentially greater running costs and less energy efficient; specification may be outdated and may need considerable re-modelling
- Conversion of existing building
- Adaptation e.g. refrigerated lorry back or shipping container: easily adapted for cold storage; can be used to hold seeds and cutting material; relatively cheap (up to £4,000); usually quite small; can only use manual plant handling; condition can vary so check carefully before use to prevent costly repair bills
- Renting off-site/sharing with other growers: good for short-term, seasonal requirements; flexible; shared costs; can be limited in availability; needs to be situated close-by; quality control may vary; off-site security may be an issue

Cold Store checklist

- Do I need short-term or long-term facilities?
- What do I need in terms of space, location and environmental control?
- Do my present facilities meet these needs?
- Will these needs change in the future?
- How much is my present CS costing?
- Is my present CS cost effective and in good condition or should I consider building a new store?
- What specification do I need and how much will it cost?
- What is my budget?
- Am I flexible and prepared to rent/share CS facilities?
- Are there suitable rented facilities nearby? What condition are they in?
- Are these CS used for fresh produce?
- Are they suitable for my requirements?
- Are there other growers in the area prepared to rent/share?
- Is there a reliable service engineer in the area?

HNS 140: Costs of cold storage

- Purchase costs vary considerably from £60,000 to £125,000 depending on use
- Average annual cost to build and run a CS £22/m² of storage area over 10 yrs (excludes cost of any building the store may be situated in)

## Plants or pot size
<table>
<thead>
<tr>
<th>No. of layers on trolley</th>
<th>Cost of CS area</th>
<th>Cost of glass area</th>
<th>Difference % othercs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large plants</td>
<td>£21.35</td>
<td>£9.12</td>
<td>-£12.23 -57.28</td>
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<tr>
<td>3 lt</td>
<td>£21.35</td>
<td>£18.24</td>
<td>-£3.11 -14.57</td>
</tr>
<tr>
<td>9cm</td>
<td>£21.35</td>
<td>£22.80</td>
<td>£1.45 6.79</td>
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<tr>
<td>Plugs</td>
<td>£21.35</td>
<td>£41.04</td>
<td>£19.69 92.22</td>
</tr>
</tbody>
</table>

## Direct area comparison between CS and glasshouse (HNS 113, 2002)

<table>
<thead>
<tr>
<th>Plants or pot size</th>
<th>No. of layers on trolley</th>
<th>Cost</th>
<th>Output per m²</th>
<th>Break-even yield</th>
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</thead>
<tbody>
<tr>
<td>Large plants</td>
<td>2</td>
<td>£21.35</td>
<td>8,105</td>
<td>3.11</td>
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<tr>
<td>3 lt</td>
<td>4</td>
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<td>2,707</td>
<td>9.49</td>
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<tr>
<td>9cm</td>
<td>7</td>
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<td>1,988</td>
<td>5.92</td>
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<tr>
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<td>9</td>
<td>£21.35</td>
<td>4,419</td>
<td>8.39</td>
</tr>
</tbody>
</table>

Any questions?

Keep a cool head