Left: MSBP staff member wearing regulation cold room clothing

Safety considerations

- It is essential that cold room doors can be opened from the inside, even when locked. Walls should contain a pressure release valve: negative pressure can develop in the room as temperature decreases, which can make opening the door more difficult.
- Staff should wear suitable cold room clothing. Establish safety procedures, including maximum working times.
- Set up measures to ensure the safety of the collections in an emergency. This could involve duplication at another seed bank.
- Include a back-up generator and spare parts for equipment
- Establish service contracts for maintenance of cold room equipment.

The walls, ceiling, doors, windows, and, where possible, the floor, will need insulating. Locally available insulating materials such as cork may be used. Where possible, apply the chosen insulation material, or at the very least, a layer of moisture-proofing, to the outside of the structure, to prevent condensation in the walls.

How is the room cooled?

The refrigeration system is installed in a plant room or cool outhouse separate from the cold room. Use two conventional vapour compression refrigeration units, both capable of operating at 66% capacity and able to maintain the room at -20°C, taking into account the heat loads generated by the lights, staff working in the room, permeation through the insulation and infiltration when staff enter the room. The condenser may be separate or part of the same unit.

Use as 'ozone friendly' a refrigerant as possible. Make sure that the pipework connecting the cooling equipment to the cold room is properly insulated.

Other essential cold room equipment (see diagram overleaf) includes:

- Drain pipe from evaporator (fitted with heater)
- Fan on evaporator (required to move air around)
- Thermostat
- Warning alarms
- Low temperature lighting
- Personnel panic alarm

Further reading

Cromarty, A.S., Ellis, R.H. and Roberts, E.H. (1990). Handbooks for Genebanks: No. 1, the design of seed storage facilities for genetic conservation (revised edition). IBPGR, Rome, Italy.

Linington, S.H. (2003). The design of seed banks. In: R.D. Smith, J.B. Dickie, S.H. Linington, H.W. Pritchard and R.J. Probert (eds), Seed Conservation: turning science into practice. Royal Botanic Gardens, Kew, UK.

Equipment specifications

Description	Model/Product	Supplier
Cold room clothing	Parka coats or one-piece suits (coveralls), gloves, boots and hats.	Various suppliers
Upright freezer with static cooling (to -20C)	Large upright freezer with digital temperature display audible alarm. Drawers or shelves are recommended.	Liebherr Group www.liebherr.com
Cold room structure	As design brief	Local cold room specialist

Please note that the above equipment is used by the Millennium Seed Bank Project and has been chosen carefully using our many years' experience. The list of suppliers is for guidance only and does not represent an endorsement by the Royal Botanic Gardens, Kew. The manufacturer's instructions must be followed when using any of the equipment referred to in this Information Sheet.

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MILLENNIUM SEED BANK PROJECT Kew

Seed bank design: cold rooms for seed storage

Technical Information Sheet_12 Simon Linington and Keith Manger, Seed Conservation Department

Orthodox seed collections should be maintained at cool temperatures, once they have been dried and packaged (refer to Technical Information Sheet 06, Technical Information Sheet 11). Seed longevity increases as temperature is lowered (storage life approximately doubles for each 5°C reduction in storage temperature). However, the increases in storage life become smaller as temperature is lowered.

Taking into account seed longevity, cost, safety and other factors (such as bio-physical stability), the Millennium Seed Bank Project (MSBP) recommends a seed storage temperature of about -20°C. A cold room is the most appropriate storage method if you need to store large volumes of accessions. A single cold room is also more energy efficient than several individual freezers (see table below). However, cryo-preservation at ultra-low temperatures may be advisable for some very short-lived seeds, provided that there is a good local supply of liquid nitrogen.

This information sheet provides advice on designing a -20°C cold room.

Above: -20°C seed storage rooms

Designing a cold room

It is important to obtain specialist advice when designing a cold room. However, seed curators and conservation practitioners should understand the basic principles in order to guide the design.

Comparing seed cooling facilities

	Temperature	Advantage	Disadvantage
Domestic refrigerator	~ 4°C	Cheap and replaceable	Relatively high temperature for seed storage, small capacity.
Domestic deep freezer	-13 to -20°C	Relatively cheap and replaceable. Upright (recommended) and chest versions	Not recommended if more than 10m³ freezer volume is required.
Purpose-built cold room	-20°C	May use less energy than individual freezers	High initial cost. Maintenance required.
Liquid nitrogen storage	-160 to -196°C	Greatest seed longevity likely. Suitable for very short-lived orthodox species.	Small seed volumes. Requires a ready supply of liquid nitrogen and an effective ventilation system.

The key questions when designing a cold room are:

Where should the cold room be located?

Locate the cold room in a cool place within a secure building at a safe site, with minimum risk of flooding or other natural disasters. If possible, locate the cold room so that it is accessed directly from a drying room. This will mean that only pre-dried air can enter, and will reduce the build-up of ice in the cold room. Drying the air in a cold room is technically difficult and expensive, and not necessary if good quality containers are used.

What size of cold room is required?

To calculate the room volume required, start with the sizes of containers to be used (see worked example overleaf). Choose different containers for collections of very small, medium and large volume (see Technical Information Sheet 06).

Cold room for seed storage: worked example

The following calculations can be used to determine the capacity of cold storage required for a seed bank. For simplicity, the worked example assumes that just one container type is used. However, it is not difficult to carry out the first part of the calculation for each size of container and to add the shelving floor areas together.

Container height (H) = 0.1m

Container width (W) = 0.05m

Number of collections per year (N) = 1000

Number of containers per collection (M) = 2

Width of shelving (S) = 0.5m

Space between top of container on one shelf and bottom of container on shelf above (L) = 0.1m

Number of years collecting (Y) = 25

or

Years of longevity of cold room structure (Y)
= 25 (for Styrofoam under light usage conditions, but depends on materials used),

whichever is less.

Assume that the height of the room will be around 2.5m and that the top of the highest containers on the top shelf will be 2m or less.

Number of shelves (A) = 2 / (H + L)
= 10 (round down to nearest whole number)

Number of containers across shelf (B) = S / W = 10 (round down)

Shelving floor area required each year (C) = {[(M * N) / B] * S * W} / A
= 0.5m² (ignoring uprights for shelving)

Total shelving floor area (D) = C * Y = 12.5m²

Total floor area (mobile shelving) (E) = D / (1 - 0.35) = 19.2m²

The floor area unoccupied by shelving may be 35% if mobile units are used or 70% for static shelving. The capital cost of installing mobile shelving units may be outweighed by reduced running costs over the life of the room, as a smaller cold room will thus be necessary.

Total room volume (F)
= E * 2.5 = 48m³

Keep air space to a minimum. For very small-seeded species, container volume may be as little as 10cm³; for some crops and forest tree species, containers may need to be many litres. At the MSBP, we use containers of 3 litres, 1 litre, 100cm³, 30cm³ and 2cm³. Containers with a square base waste less space than those with a round base. Select shelves of appropriate width to minimise wasted space. Add bins or drawers to the shelves to better organise the collections.

Do your calculations, using the worked example above, give a sensible estimate? A small seed bank will require a cold room volume of perhaps 35m³, whereas an international seed bank will need cold room space of 10 times this volume. If the calculated volume is less than about 10m³, deep freezers might be a better option. If the calculated volume is larger than 50m³, consider splitting the volume between two or more rooms.

Having estimated the floor area required, mark it out on the ground to get a feel for what the room might look like. Consider allocating space adjacent to the cold room for potential future expansion due to unforeseen demands.

What material should be used to construct the cold room?

Preferably, the cold room should be constructed from 100-200mm thick pre-fabricated Styrofoam panels. The greater the thickness of the panels, the greater the initial cost of the structure, but the lower the long-term running costs.

- Build walls, ceiling and doors (main entry door plus a secondary, emergency exit) from Styrofoam panels.
- Construct floors from Styrofoam panels topped with plywood and a non-slip steel plate.
- Include an air gap or a heater mat underneath the door in all temperate locations (and perhaps some other locations, seek local advice) to prevent the ground from freezing.
- Take care with shelf fixing points. Design floors to take the weight of fully-loaded shelves.
- Make sure that windows in walls and doors are double glazed, with heated seals.

If resources are limited, it may be possible to convert an existing brick or wood structure into a cold room.

Below: Seed collections 'double-packed' in a cold room - approximately thirty 30cm³ universal bottles fit into each 3 litre preserving jar

General layout of one of the cold rooms within the Millennium Seed Bank

48m² floor area (3.0m internal height) room, constructed with 0.2m thick extruded polystyrene panels, cooled by a direct expansion refrigerant system (4kW consumption) and designed to hold approximately 25,000 collections (some 6,000 litres of seeds). The refrigeration unit is held in a separate location from the cold room and is connected to the evaporators by pipe work. The condensers should be sited on the outside of the seed bank building.