From Len Caddick CSIRO
"Ute Guide" Handbook.
see: Grain Storage file.

If for some reason entry is essential, seek the help of your State occupational health and safety organisation (WorkCover), which should be able to provide guidelines for the safe entry into a confined workspace. These will be stringent and complex, but they illustrate the very real hazards of the activity.

Unsealed bins

Most existing on-farm storage structures in the eastern States of Australia are unsealed. Unsealed grain storage structures present a major problem once the grain becomes infested. Therefore, it is particularly important that every effort be made to reduce the risk of infestation by appropriate undertaking hygiene in and around the bin at all stages in the harvest and storage cycle. All bins not able to meet a pressure test standard must be considered unsuitable for reliable fumigation using either phosphine or carbon dioxide.

The following insect management measures are possible in existing unsealed structures.
1. The best approach on most occasions is to install aeration, which will limit insect growth by keeping the grain cool.
2. Sealing the structure for fumigation is possible, but may not be economically feasible, or long lasting.
3. The application of registered grain protectants where these do not interfere with the grain's end market/use.
4. Admixture of diatomaceous earth (eg. Dryacide®) where the grain is for use on-farm only.

The use of aeration or sealing a bin requires planning and action before the structure is filled. A grain protectant or diatomaceous earth is best applied as the bin is filled, or during emptying and refilling. The use of a chemical protectant or diatomaceous earth restricts and requires a definite knowledge of the end-use of the grain.

Fumigation in unsealed bins and sheds

Bins and sheds that require fumigation should be sealed. Normal fumigation of unsealed stores with phosphine is poor practice. However, it is still permitted for structures of less than 300 t capacity for some phosphine formulations. Registered rates for phosphine in unsealed stores are 5 g per cubic metre capacity. Procedures for use are given on the label. Fumigation at these rates may lead to residues above permitted levels in the treated grain. Unsealed structures do not retain fumigant for long enough to give a complete kill of all stages of insects, even at high dosage rates. Fresh air entering through the leaks creates havens where pests can survive, and it can be expected that insect infestation will soon become serious again.

Carbon dioxide (CO_2)

Treatment of grain with food-grade carbon dioxide (CO_2) in a sealed silo is one of the few acceptable ways of disinfecting and protecting commodities destined for the organic food market. Carbon dioxide treatment is not difficult but is more demanding than conventional phosphine fumigation.

The complete process consists of four critical stages - (i) sealing the storage, (ii) confirming the storage is sealed, (iii) adding the carbon dioxide, and (iv) waiting for the carbon dioxide to work.

The carbon dioxide concentration needs to be above 35% for 15 or more days for a treatment to kill all stages of all insects. This can be achieved by a single addition of gas in a reflective (white or Zincalume®) and adequately sealed bin.

Procedures for carbon dioxide (CO_2) treatment of bulk grain in small bins (less than 300 t)

Following is a checklist of equipment essential to carry out a successful carbon dioxide treatment:

- ❑ A sealed silo, or a silo able to be sealed to a high standard of gas-tightness, fitted with gas inlets at top and bottom. The user needs a point, preferably at the top of the silo, to sample gas concentration in the headspace.
- ❑ Silicone sealant or butyl mastic and an application gun for sealing purposes.
- ❑ An oil-trap pressure relief valve. Apart from the initial pressure test, a pressure and vacuum relief valve is important to balance gas pressure during environmental heating and cooling of gases in the storage bin. Extensive gas loss can occur if a pressure relief valve is not fitted.
- ❑ If the silo is not fitted with a transparent oil-trap pressure relief valve, then a U-tube manometer is needed to undertake a pressure test.
- ❑ A source of compressed air for pressure testing the silo.
- ❑ At least one 30-kilogram cylinder of food-grade carbon dioxide per 15 tonnes of storage capacity plus one extra cylinder. For example, two cylinders for 15 t, three for 30 t and four cylinders for 45 t. In partially-filled silo bins, one 30-kilogram cylinder of carbon dioxide will be required per 10 tonne of storage capacity.
- ❑ A carbon dioxide pressure regulator with a fitting to connect to flexible high-pressure rated plastic tube.
- ❑ Several lengths of plastic tubing to go from the ground to the top of the bin and back. The diameter of the tubing needs to fit the gas inlets on the silo.
- ❑ Device to measure carbon dioxide concentration accurately. Oxygen concentration can also be measured and the build-up of carbon dioxide calculated using a conversion chart.
- ❑ Soapy water (2% household detergent) and spray pump to check for leaks.
- ❑ A few rolls of self-adhesive plastic tapes - 18-millimetre electrical and 50mm duct tape are the most useful for sealing purposes.

Diagram of carbon dioxide treatment method
{Insert diagram}

How to treat a bin with carbon dioxide

After the pressure test has been performed successfully, carry out the following steps to complete the treatment:

- ❑ Disconnect the U-tube manometer.
- ❑ Fit the pressure regulator to the cylinder.
- ❑ Connect the carbon dioxide cylinder to the bottom using suitable high-pressure hosing from the regulator to the inlet port.
- ❑ Ensure there is an opening at the top of the silo to allow the air displaced by the carbon dioxide to escape.
- ❑ Turn on the carbon dioxide cylinder valve then open the pressure regulator. The flow of carbon dioxide should result in the inlet tube becoming just covered with frost over a number of minutes.
- ❑ Add carbon dioxide until the concentration at the top of the bin reaches 70-80% or the cylinder freezes and the gas flow is reduced.
- ❑ If the cylinder freezes disconnect it and connect another cylinder. The frozen cylinder will slowly thaw and can be used later if needed.
- ❑ When the carbon dioxide concentration at the top of the bin reaches 70-80% or the full contents of the cylinders are used, stop adding gas.
- ❑ Close and seal the top of the silo.

Exposure period

If the pressure test meets the accepted standard for gas tightness (a halving-time of three minutes in a full silo bin), then the carbon dioxide concentration in the headspace and upper portion of the grain bulk should remain higher than 35% for 15 days.

If the pressure halving time is less than three minutes gas may need to be added daily to stop the concentration falling to less than 35%. Adding carbon dioxide every day is complicated and expensive, since the concentration needs to be measured regularly and excessive gas is used.

If the bin failed the pressure test by a considerable margin, the level of sealing is poor and the continual addition of carbon dioxide will not guarantee the required concentration is maintained.

Carbon dioxide is heavier than air and the gas tends to layer down to the leakage point in a silo. Grain held in the upper part of the silo is therefore most vulnerable to low carbon dioxide concentrations.

Cost of treating with carbon dioxide

It is hard to give a definite cost for carbon dioxide treatments because of the way compressed gases are priced. They have variable components to the price, such as cylinder rental, transport cost and gas costs. The gas cost for carbon dioxide is in the range $1.50 to $2.90 per treated tonne in a full storage. This range of costs is based on prices quoted in February 2001 by normal commercial suppliers in the southern NSW grain-growing areas.