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Stored cereal grains and pulses — Guidance on the detection of infestation by live invertebrates by trapping

Céréales en grains et légumineuses stockées — Lignes directrices pour la détection de l'infestation par des invertébrés vivants par piégeage

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 16002 was prepared by Technical Committee ISO/TC 34, *Food products*, Subcommittee SC 4, *Cereals and pulses*.

Introduction

Within the food sector, cereal grains are the commodities which are traded in the greatest quantities. They often form nations' strategic food reserves. They can be stored for varying periods and under differing conditions, and are always susceptible to invertebrate infestation. The risk of infestation varies with the storage methods used, with time, and with the ambient temperature and humidity in the storage area. Even short storage periods in the tropics can result in the development of significantly damaging infestations.

If cereal grains become infested, the consequences can be damage, loss of quality, loss of value, and deterioration of nutritional value, and can lead to illness in animals and humans.

Infested cereal grains can act as a reservoir for the subsequent infestation of sound cereal grains. Infestation can lead to rejection of deliveries, contractual problems, loss of international trade and reputation, and problems with phytosanitary certification under the International Plant Health Convention.

Effective detection of infestation enables informed decisions to be made about if and how cereal grains require remedial treatment. Such treatments, examples of which are given in Annex D, may have implications for the subsequent use of such cereal grains in products destined for animal and human consumption.

Many methods may be used for the detection of live invertebrate infestation in stored grains, but it is considered that the most satisfactory systems for their detection in stored cereal grains and pulses are based on trapping, as described in this International Standard. Some of the other methods are listed in Annex A. These various methods have their own advantages and disadvantages. Methods based on the removal and subsequent assessment of samples are inherently less suitable for insect detection due to the sampling method.

Trapping for invertebrates in the storage of cereal grains and pulses can be used to detect the existence of pests, to collect specimens for accurate identification, to assess their numbers if action thresholds have been set, and to monitor invertebrate populations after the application of control measures to test their effectiveness.

The standard method (ISO 13690) for the sampling of cereal grains and pulses specifically does not apply to sampling for the detection of infestation. There are standard methods for the detection of hidden infestation [see ISO 6639 (all parts)] but no other International Standard exists for the detection of live invertebrates moving freely within cereal grains and pulses stored in bulk or in bags.

Stored cereal grains and pulses — Guidance on the detection of infestation by live invertebrates by trapping

WARNING — The placement of traps within bulk grain stores will involve access to the grain surface. It is important that operator safety is considered. Access into closed storage silos may be hazardous and due assessment must be made of the risks involved, including entry and exit procedures and the possibility of the presence of noxious gases.

For these reasons, this standard is most applicable to grain which is stored in bulk in open bins and silos, and in flat or floor stores and in sack stores.

1 Scope

This International Standard describes methods for the detection by trapping of live invertebrates in cereal grains and pulses stored in bags or in bulk.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
grains
cereal grains and/or pulses

2.2
beetles
species (members) of order *Coleoptera*

NOTE Many weevils within the coleopteran family Curculionidae are highly significant pests of stored cereals, being "hidden infestations" for much of their life cycles. Several other coleopteran families include important grain damaging species.

2.3
infestation
live insect and mite species which, during some stage(s) of their life cycle, are capable of causing damage to the grain

NOTE These are also known as "pest species".

2.4
invertebrates
multicellular animals without spinal column, with special reference to insect and mite species within the phylum *Arthropoda*

2.5
moths
species of the order *Lepidoptera* (*Heterocera*), which are less brightly coloured than butterflies and fly mainly at night

NOTE Butterflies (*Rhophalocera*) and moths (*Heterocera*) belong to the same order *Lepidoptera*, but butterflies are not encountered in grain storage.

2.6
natural pheromone
chemical scent produced by an animal to affect the behaviour of other animals of the same or very closely related species

2.7
synthetic pheromone
replica pheromone molecule synthesized to duplicate the effect of the natural pheromone

NOTE Synthetic pheromones are frequently used as sex scents to confuse or decoy males of a species, for example in moth traps in agriculture and food storage.

2.8
trap
device designed and intended to retain target species or groups, which have entered its structure, or to entice and encourage them to remain within the device

3 Principle

Insects and mites are detected by physical entrapment, or retention by means of food or other attractants, or both. Physical entrapment devices retain all, or the majority, of invertebrates which enter them since they are designed to preclude escape. Food or other attractants may also be used in devices which attract invertebrates but which do not subsequently prevent their escape. Their effectiveness then relies on the attractiveness of the lure, encouraging a large proportion of the local target invertebrate population to remain in the device.

Since trapping relies upon insect and mite activity, trapping results in cold or very hot conditions may be markedly different from results obtained in the "normal" range between 15 °C and 40 °C.

4 General

4.1 The presence of insects and mites in grain storage depends on a range of factors.

The standard of hygiene (sanitation), the type of pest management in operation (temperature and humidity control, percussive methods, for example) and the potential uses to which the grain will be put, can all have a bearing on the significance of insects and mites detected through trapping. See also ISO 6322-2.

4.2 Physical traps depend for their effectiveness on the natural movement of insects, and their entry into trap structures from which they cannot or choose not to escape.

4.3 A baiting device depends on the principle that insects are attracted to a food or other attractant, and once in the vicinity of the bait, they are likely to remain.

4.4 Traps for flying insects depend on the principle that adult insects will fly towards an attractant housed within a trap and are then retained by the device.

4.5 It should be noted that the attractants used in some systems are synthetic pheromones which are mostly effective only for one genus of species and usually for only one sex of that species, often the males. Food-based attractants are generally attractive to many species.

4.6 Unbaited trap systems depend entirely on invertebrates encountering the device by chance and then being retained by the design of the trap. This type is sometimes called "blunder traps".

4.7 The range of insect and mite grain pests which could be expected in grain storage include the following:

a) grain beetles and weevils whose adults cannot fly;

b) grain beetles and weevils whose adults can fly;

c) moth species whose adults can fly;

d) grain mites which cannot fly and which are only just visible to the naked eye.

The choice of the best trap type is dependent upon the expected range or spectrum of pests and the physical (climatic and local store) conditions under which it is expected to operate.

5 Trap types

Many different types of trap are available. Those listed in Annexes B and C are representative of trap types available in many countries, and are included as a guide to their construction and design. It is known that the use of the various types of trap can give rise to differing results of relative estimates of the infesting pest population within the same storage. Locally made traps, following the principles covered in this International Standard, will provide valuable information on infestation, but their level of efficacy may not be known and thus their results will not be directly comparable with other traps.

Annex B gives examples of trap types, and this and the illustrations in Annex C are included to help in the selection of suitable trapping methods in a variety of food storage situations.

6 Method of trapping

6.1 Trapping in bulk grain

6.1.1 Trapping crawling insects and mites in bulk grain

The variable conditions to be considered are

- type of storage system,
- access to the grain surface,
- exposure to weather,
- tonnage in each bulk mass, and
- length of expected storage period.

The most suitable type of trap should be selected. Probe-type traps (Figure C.1) are inserted in pairs, one trap into the upper 10 cm to 30 cm of grain, and the second trap at a depth of up to 200 cm of grain. Covered combination pitfall/probe-type traps (Figure C.3) should be used in pairs, the upper trap just level with the grain surface and the lower trap at a depth of about 20 cm to 30 cm in the grain. Open pitfall-type traps (Figure C.2) are positioned level with the grain surface. Dust on internal surfaces of the open pitfall trap may help mites, moth larvae and some beetles (notably the rice and maize weevil, *Sitophilus oryzae* and *Zea mays*) which are able to climb some shiny plastic surfaces to escape. For this reason, the inner surface of the rim is often treated with a dried water solution of PTFE (polytetrafluoroethene), which can be cleaned off and replaced at intervals according to the rate of deterioration.

The baited mesh bag trap (a bag made from 2 mm plastic mesh containing mixed food attractant) (Figure C.9) can be used directly on the grain surface, although this is inadvisable if there is significant rodent activity in the store. Its efficacy declines with the age of the food constituents. In some countries, carob or locust bean is chosen as the component most attractive to invertebrates; its aromatic odours gradually decrease on exposure. Other component foods include whole or cracked wheat or maize, flaked maize, oats, groundnuts, and brown rice. The choice of formulation will depend on local supplies, and also on the nature of the grains being stored and known or suspected preferences of target pest species. Invertebrates will remain inside the perforated bag and food by choice rather than by preventing their escape. In most bulk storage situations, the baited mesh bag is more suitable for detecting invertebrates in the structure of the stores, or in sack stores.

All trap types used in bulk grain should be secured by string or other material to marker canes or to the store structure, to ensure their easy location and subsequent recovery. A plan or drawing of the grain surface where the traps are in use can be kept to aid recording of results.

Storage mites, which are up to 0,5 mm length, are difficult to see with the unaided eye, and are frequently dispersed amongst foods and spillage, making visual inspection even more difficult. For the detection of mites within the bulk store structure, attractant lure-type traps are currently the most effective.

A baited plastic refuge-type trap relies on the attractiveness of the high moisture content food-based lure inside a chamber of localized high humidity to encourage mites to enter and remain inside the trap. There is no method to prevent mites from dispersing from the trap, which they will do as the food lure dries out. Therefore mite counts in the trap are only a guide to mite activity, and the frequency of monitoring may need to be increased to optimize count numbers whilst the lure remains at its highest humidity and most attractive.

The baited mesh bag trap can be used for the detection of mites in almost any situation in a store. Its efficacy will be less than the baited refuge trap, because of the lower internal moisture content of the food constituents and the resulting lower humidity. Mites remain inside the perforated bag and food by choice rather than by being unable to escape.

Mite traps can be placed wherever is convenient, at floor level, at approximately 2 m or 3 m intervals, or closer together in targeted trapping. Servicing the baited-refuge mite traps is generally by removal of the entire trap for laboratory assessment, and replacement by another trap. In some designs the replacement is a recycled plastic container with a new lure installed. Replacement intervals depend on the lure remaining fresh and moist, and are generally about 7 days to 10 days. This vary depending on local climatic conditions and, although most baits contain mould inhibitors, the onset of fungal development within the trap may be the practical replacement time.

6.1.2 Trapping flying insects in bulk grain

The trap types suitable for flying insects (Figures C.4, C.5 and C.8) can be used directly on the grain surface, or suspended between 100 cm and 300 cm above the grain. When deciding trap placement in the grain store, consideration must be given to the patterns for trap placement and for retrieving the traps at each recording interval.

All types, except the exposed adhesive strip trap, are satisfactory in dusty grain storage situations. However, it should be noted that excessive dust deposits may impair their retention efficacy. Where trapping is dependent on pheromone lures, it is important that the lures be replaced according to the manufacturer’s instructions, to maintain consistent attraction. In hot tropical climates, pheromone lure renewal may need to be more frequent than standard recommendations to take account of a more rapid rate of evaporation. Unused lures should also be stored at cool temperatures until required.

6.2 Trapping in sack stores

6.2.1 General

For effective detection, trapping techniques should be selected according to the type of invertebrate expected. See 4.7 for more detail. No trap types are mutually exclusive and a combination of types can be used in the same store.

6.2.2 Trapping crawling insects in sack stores

The distribution of traps in a sack store depends on the stacking arrangements and the need for regular inspection of the traps. Some trap types need more frequent maintenance where some of the components should be replaced at recommended intervals. Examples include pheromone dispensers, adhesive base sheets and strips, and oil-impregnated paper disks, all of which have a variable but limited effective life.

As a general guide, traps should be placed in the darker and slightly less accessible areas of the store where invertebrate activity is likely to be greatest, and close to or amongst the bags and pallets. Spacing need not be constant but generally traps can be placed at about 3 m to 6 m linear spacing around the bases of stacks and wall/floor junctions. Vertical distribution will depend on the type of trap and the stacking arrangements. Where possible, traps should also be placed between sacks or, if pallets are used, then flat within the pallets for ease of retrieval.

The folded cardboard box trap with adhesive internal base sheet (Figure C.8) and the plastic tray trap with lid and replaceable adhesive base sheet (Figure C.7) are both dependent on the adhesive being suitably sticky to retain invertebrates which enter the traps. These trap types are seldom baited. However, where food-based sachets or tablets are available to bait the traps, these lures should be replaced at the intervals recommended by the manufacturer.

The flat-based pitfall trap with domed perforated cover may be baited with food-lure tablets or sachets, or with pheromone capsules. This trap type depends on the smooth and shiny internal surfaces preventing invertebrates from escaping, and is therefore less affected by dusty atmospheres in stores. However, mites, moth larvae and some beetles (notably the rice weevil, *Sitophilus oryzae*) are able to crawl up the shiny plastic surfaces and escape.

The corrugated or sheet card cover with integral plastic pitfall type (Figure C.6) is usually baited with a small absorbent paper disk treated with a few drops of an attractive vegetable oil (for example maize oil, sunflower oil, rape oil). Depending on which design of trap is used, airborne dust may be a problem by covering the oil-impregnated disk.

The baited mesh bag trap (Figure C.9) can be used in almost any situation in a sack store. Its efficacy declines with the age of the food constituents. Invertebrates remain inside the mesh bag and food by choice rather than by being unable to escape. Typical food components include kibbled carob pods (locust bean), groundnuts and wheat. Flaked maize has replaced nuts for use in sensitive parts of some food processors where nut contamination may be an important consideration. Oats are also a very attractive food for many beetle species. Brown rice has been successfully used on its own in milled rice stores.

6.2.3 Trapping flying insects in sack stores

Traps used for detecting flying insects are usually positioned in open air spaces, on the top and sides of bag stacks, or on the walls of the store. Their positioning should take account of any servicing required and the need for regular inspection. In general, flying insect traps are baited with pheromone-impregnated capsules and/or food-based lures, and these “targeted” traps are less dependent on accidental encounters by insects.

The bucket- or funnel-type pheromone-baited moth trap (Figure C.4) is most frequently suspended from convenient overhead ceiling or racking positions, or placed directly on the top of stacks. Access for checking moth catches is important, and there should be a method of retaining adult moths once inside the bucket/receiver. This can be achieved by the installation of small dichlorvos-impregnated strips inside the receiver (where these are permitted by national and local regulations), or by placing an adhesive strip either inside the flat base or around the inside walls of the receiver. The trap should also be accessible for regular renewal of the pheromone capsule according to the manufacturer’s or supplier’s recommendations.

The cardboard or corrugated plastic tent-type trap (Figure C.5) is suspended in a similar manner to the bucket-type trap. It also has a pheromone-impregnated capsule, which requires routine replacement. However its method of trapping depends on an adhesive basal surface beneath the tent structure. Due to the large openings at each end, this type of trap can be affected by airborne dust and the adhesive surface can become ineffective quickly in dusty conditions. A variation of this design uses adhesive surfaces under the top cover, and on the facing base. This type often has slightly restricted end openings, reducing the ingress of airborne dust particles.

Traps which capture flying insects, and are based on an exposed adhesive strip baited with an impregnated pheromone capsule, require replacement of the capsule at routine intervals, according to the manufacturer’s or supplier’s recommendations. The trap’s exposed adhesive surfaces will be adversely affected by airborne dust more quickly than traps with internal adhesive surfaces. Many traps of this type are intended to be completely replaced at pheromone renewal time; their construction is simple and relatively cheap. Positioning of these traps is generally similar to those above, except that they are not suitable for resting directly on the top bags of the stack.

Traps designed around a folded shallow cardboard “box” (Figure C.8) with open ends or open sides may be placed wherever convenient, but usually more than 1,5 m from the floor for best effect. They may be suspended from racking, from purpose-made stands, or placed directly on the bags of the stack. They are usually baited with an impregnated pheromone lure (sometimes also with a food-based lure), which will require routine replacement according to the manufacturer’s or supplier’s recommendations. Many traps of this type are completely replaced at pheromone renewal time since their construction is simple and designed to be cheap. Their internal adhesive surfaces are well-protected from normal air-borne dust and only in exceptional conditions will dust accumulations on the adhesive occur more rapidly than the normal routine trap replacement schedule.

6.2.4 Trapping mites in sack stores

Storage mite pests, which are up to 0,5 mm length, are not easy to see with an unaided eye, and are frequently dispersed amongst foods making visual inspection even more difficult. The use of attractant lure-type traps is currently the most effective method for the detection of small numbers of mites in food storage. A baited plastic refuge-type trap relies on the attractiveness of the high moisture content food-based lure inside a chamber of localised high humidity to encourage mites to enter and remain inside the trap. There is no method to prevent mites from dispersing from the trap, which they will do as the food lure dries out. Therefore mite counts in the trap are only a guide to mite activity, and the frequency of monitoring may need to be increased to optimize count numbers.

The baited mesh bag trap (Figure C.9) may be used for the detection of mites in almost any situation in a bag store. Its efficacy will be less than the baited refuge trap, because of the lower internal moisture content of the food constituents and the resulting lower humidity. Mites remain inside the perforated bag and food by choice rather than by being unable to escape. However, if mites are present in a particular area of a store, the humidity must be adequate for mites (usually above 60 % relative humidity), and the bait bag and its contents will rapidly equilibrate accordingly over a 24 h to 36 h period, extending the period when the bait bag is effective as a mite attractant trap, before mould development reduces its practical use.

Mite traps may be placed wherever convenient, at floor level or amongst the bags and racking, and at approximately 2 m to 3 m intervals, or closer together in targeted trapping. Servicing the baited-refuge mite traps is generally by removal of the entire trap for laboratory assessment, and replacement by another trap. In some designs, the replacement is a recycled plastic container with a new lure installed. Replacement intervals depend on the lure remaining fresh and moist, and are generally about 7 days to 10 days. This will vary depending on local climatic conditions and, although most baits contain mould inhibitors, the onset of fungal development within the trap may indicate the practical replacement time.

7 Record of findings

Simple tabulated recording sheets should be devised for noting the results of invertebrates caught, trapped or present in or on the various traps described above. Information required should include the following:

a) grain storage bin/silo/bay name or number (as appropriate);

b) grain type being trap monitored;

c) average moisture content of bulk or bagged grain;

d) surface moisture content of bulk grain, if significantly different from the average;

e) average ambient temperature of the store during a working day;

f) average humidity of the store during a working day;

g) trap type;

h) trap position;

i) trap number;

j) date when trap was placed;

k) date when trap was serviced (replacement lures, etc.);

l) days (or weeks) from last count;

m) date of insect/mite counts;

n) number and species trapped;

o) life stages present (if this is significant for the control of the infestation).

Other information may be collected as required (e.g. name of technician, destination of grain, weather on the day of sampling).

8 Interpretation of findings

8.1 The accurate identification of invertebrates captured in traps is essential to enable their importance and possible control methods to be evaluated. Identification of storage invertebrates is not a common skill and specialist help may be needed.

8.2 The significance of invertebrates in traps depends on the species and the situation. Human food grains are generally stored to a higher standard than animal feed quality grains. In some cases, pest number thresholds may be set which, if exceeded, indicate the need for appropriate pest management action, such as fumigation. The differences in the magnitude of such thresholds reflect the significance of the pest, and the rigour of the quality standards applied to the grain.

8.3 Since correctly chosen traps will be more reliable in detecting insects and mites than the normal grain trade sampling methods (which are not designed for invertebrate detection), it is essential that, where applicable, both seller and buyer agree on the method of detection to be used to implement the action threshold.

8.4 Trap types and the service schedules associated with each trap type can be standardized. However, similar traps used in different bulk or bag stores of grain may result in the detection of widely varying levels of invertebrates. Variation in efficacy may be for a number of reasons, including temperature and moisture content of grains, different varieties of the same grains, and from climatic differences. See also 6.1 for additional comment on trap variability.

Whilst trapping provides only a relative estimate of invertebrate numbers, it does provide information on trends — whether the pest population is increasing or decreasing — allowing the initiation, or modification, of control strategies.

8.5 This International Standard does not specify the significance of different levels of invertebrates detected in traps used in grain storage. In some cases, national standards of acceptability may apply; in others, trading specifications may cover this aspect.

Annex A
(informative)

Other methods for the detection of live invertebrates in stored grain

The following methods are sometimes used:

- acoustics;
- aspiration*;
- carbon dioxide evolution*;
- flotation*;
- heat development and evolution*;
- near infrared*;
- ninhydrin staining*;
- nuclear magnetic resonance*;
- probing/spearing*;
- sieving*;
- uric acid detection*;
- visual inspection**;
- X-ray*.

Methods marked with an asterisk rely on sampling the commodity. Sample extraction is recognized not to be the most effective method of determining invertebrate presence in grain storage. Some of these methods are described in ISO 6639-4.

The method marked with two asterisks relies on observations relating to selected parts of the grain in store, rather than the removal of discrete samples for further examination.

Annex B
(informative)

Examples of trap types for detecting live invertebrate infestation in stored grain

Subclause	Storage situation	Trap type
6.1.1	Bulk grain: crawling insects and mites	Probe trap Pitfall trap Combined probe/pitfall trap Baited mesh bag
6.1.2	Bulk grain: flying insects	Bucket- or funnel-type trap Cardboard or corrugated plastic tent trap Exposed adhesive strip trap Shallow open-ended/sides card box trap
6.2.2	Sack stores: crawling insects	Folded cardboard box with adhesive base sheet Plastic tray with lid and adhesive base sheet Flat-based pitfall trap with perforated domed cover Corrugated or sheet card cover with integral plastic pitfall Baited mesh bag
6.2.3	Sack stores: flying insects	Bucket- or funnel-type trap Cardboard or corrugated plastic tent trap Exposed adhesive strip trap Shallow open-ended/sides card box trap
6.2.4	Sack stores: mites	Baited-refuge trap Baited mesh bag

Annex C
(informative)

Illustrations of examples of the different trap types used for the detection of live insects and mites in stored grain

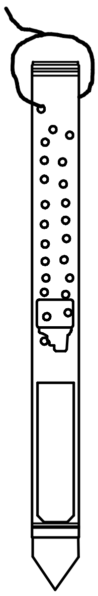

Figure C.1 — Tubular plastic probe trap

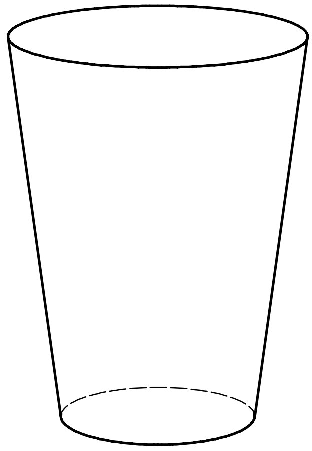

Figure C.2 — Simple plastic pitfall trap

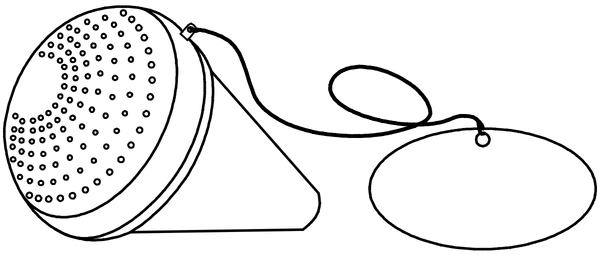

Figure C.3 — Combined pitfall/probe trap

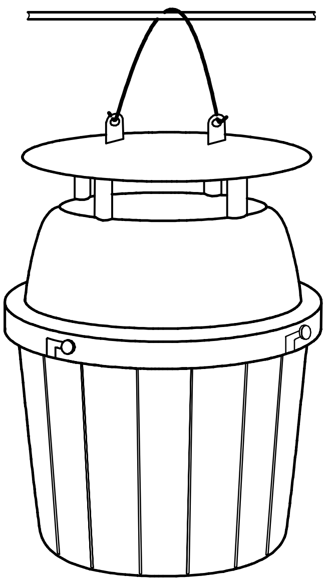

Figure C.4 — Funnel or bucket-type trap

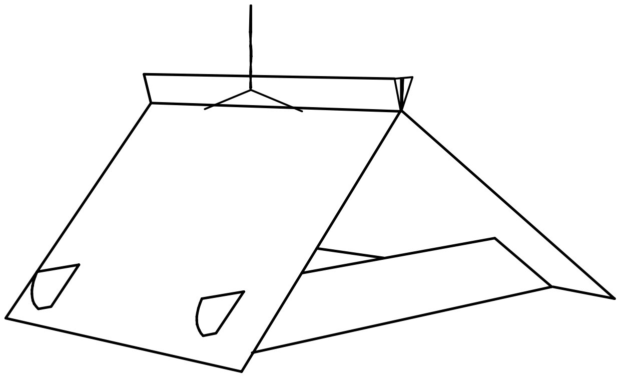

Figure C.5 — Cardboard or corrugated-plastic tent trap with adhesive internal surfaces
(sometimes called delta traps)

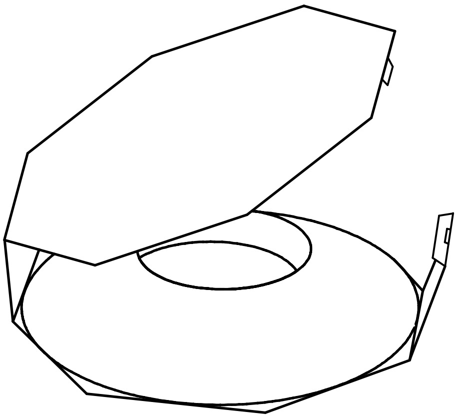

Figure C.6 — Card cover with integral plastic pitfall and absorbent pad for attractant oil

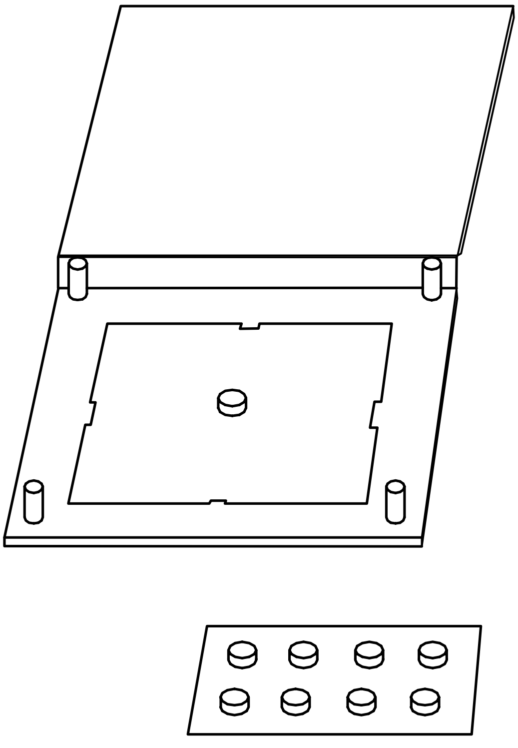

Figure C.7 — Plastic tray with hinged lid and adhesive base sheet

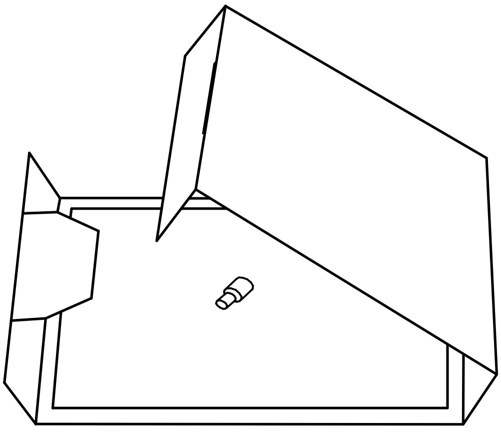

Figure C.8 — Folded cardboard box with adhesive base sheet

Figure C.9 — Food-baited plastic mesh bag

Annex D
(informative)

Examples of treatment methods for grains infested by invertebrate pests

D.1 Physical treatment methods

The following examples are in use:

- heat disinfestation (in excess of 55 °C for > 30 min;
- low temperature treatment (grain held below –15 °C for at least 1 week);
- percussion (as in a centrifugal-action spinning machine used in milling);
- long-run coarse-action conveying equipment (most appropriate to reducing mite infestations);
- cleaner-auger operations.

D.2 Chemical (pesticide) treatment methods

The following examples are in use:

- toxic fumigation (usually with either methyl bromide or with phosphine gases);
- natural gas fumigation (with either nitrogen or carbon dioxide).

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ICS 67.060

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