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Storage of cereals and pulses —

Part 3:
Control of attack by pests

Stockage des céréales et des légumineuses —
Partie 3: Contrôle de l'attaque par les déprédateurs

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 6322-3 was prepared by Technical Committee ISO/TC 34, *Agricultural food products.*

This second edition cancels and replaces the first edition (ISO 6322-3 : 1981), of which it constitutes a minor revision.

ISO 6322 consists of the following parts, under the general title *Storage of cereals and pulses*:

— *Part 1: General considerations in keeping cereals*

— *Part 2: Essential requirements*

— *Part 3: Control of attack by pests*

Annexes A and B of this part of ISO 6322 are for information only.

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Storage of cereals and pulses —

Part 3:
Control of attack by pests

1 Scope

This part of ISO 6322 gives guidance on means of controlling attack by pests on cereals and pulses in storage.

NOTE — Other aspects of storage of cereals and pulses are dealt with in ISO 6322-1 and ISO 6322-2, and the determination of insect infestation is dealt with in ISO 605, ISO 6639-1, ISO 6639-2, ISO 6639-3 and ISO 6639-4.

2 Vertebrate pests

2.1 General

The ability of birds, rats, and mice and other rodents to feed on grain is not limited by the quality or condition of the grain but only by its accessibility.

The effects of attack by birds, rats, and mice and other rodents are contamination, spillage, loss in mass and reduction in quality. Contamination may, for example, prevent wheat from being used for flour milling because of an excessive count of rodent hairs in the finished flour.

Attention to hygiene and proofing of stores against access are the principal preventive measures, although anticoagulant baits (such as warfarin) may also be used for routine control of rats and mice. The use of an acute poison may be necessary if resistance to anticoagulants appears in rat or mouse populations.

Birds should be excluded from grain stores by bird-proofing. Birds may be trapped, shot or poisoned, but in some countries bird protection laws and public opinion place considerable limitations on control measures.

2.2 Control

Rats and mice may be controlled by trapping, or by the use of a bait incorporating a poison which acts within a few minutes of ingestion (acute poison) or by one which acts over a period (chronic poison) or by fumigation with gas. Fumigation is generally used as a part of an integrated control system, as it normally gives no residual protection.

Fumigation against rodents is normally performed at lower dosage rates and for shorter periods of exposure than those required for insect control. It follows that an insect fumigation also controls rodents. Methods involving fumigation or the use of acute poisons should be carried out only by properly trained persons, as specified by national governmental regulations.

3 Invertebrate pests

3.1 General

Attack by insects and mites is influenced by the accessibility of cereals and pulses and also by the type and condition of the grain.

Attack may not only lead to loss in mass and to contamination, but may alter the condition and quality of the grain.

Infestation of grain both by true storage pests and by field crop pests, for example Thysanoptera (thrips) or Lepidoptera [for example *Apamea sordens* (Hufn.) (rustic shoulder knot moth [1])], may result in the contamination of milled products with insect fragments.

3.2 Onset of infestation

3.2.1 Pulses

Pulses are liable to be attacked during growth by various moths and pulse beetles (Lepidoptera and Coleoptera) [for example *Bruchus pisorum* (L.) (pea beetle)], which lay eggs on the developing pods. The larvae penetrate the seeds and continue

1) The common names for insects and mites used in this part of ISO 6322 are those generally used in the United Kingdom. Common names in other languages are not necessarily direct translations of the names which appear here, and should be confirmed by an expert in each country. It is recommended that the appropriate common names be substituted in corresponding national standards.

to develop in the dry seeds after harvest, adult pulse beetles eventually emerging and flying to the fields to start the cycle again. Some species [for example *Callosobruchus maculatus* (F.) (cowpea beetle) and *Acanthoscelides obtectus* (Say.) (dried bean beetle)] are capable of continuing to reproduce on the dry peas and beans. Seeds containing pupae or adults ready to emerge can be recognized by the thin outer layer of the seed coat, or "window", covering the end of the exit tunnel. Seeds from which beetles have emerged have clean round holes.

The storage of pulses should therefore be organized on the assumption that they are already infested when taken into store. The risk depends on local circumstances (climate, field control methods, etc.), being greatest in the tropics where conditions favour survival and continuous rapid development of pests.

3.2.2 Cereals

Field infestation of cereals by storage insects occurs mainly in the tropics and sub-tropics but also in the warmer parts of temperate regions. It is normally caused by insects flying out from storage buildings to lay eggs on ripening crops. Some improved varieties of hybrid maize with short sheath leaves surrounding the cob are particularly liable to such infestation. Insects causing such infestation are mainly *Sitotroga cerealella* (Oliv.) (Angoumois grain moth) and *Sitophilus zea-mais* (Motsch) (greater maize weevil).

In most temperate countries, infestation by storage insects usually starts after the harvested crop has been placed in store, but may commence immediately if the combine harvester or sacks harbour insect pests.

Storage of cereals in areas where field infestation by storage insects may occur should take this risk into account. Storage of cereals in most temperate areas can be organized on the basis that grain from the field is free from infestation, except by certain species of mites.

Some species of mites carried with grain from the field can continue to breed in store (for example *Tyrophagus longior* Gerv.) but, more commonly, the dominant mites are true storage species [for example *Acarus siro* L. (flour mite)].

Mites are a particularly grave problem wherever grains are stored under high atmospheric relative humidities or their moisture content exceeds 15 % (m/m), even when the temperatures are too low for insect development.

3.3 Factors affecting insect and mite development

A few species of insects [for example *Sitophilus granarius* (L.) (grain weevil)] can attack completely sound grain, but abrasion of the seed coat, breakage during harvesting and movement, and admixtures of cereal dust facilitate attack by many other species of insects and mites [for example *Oryzaephilus surinamensis* (L.) (saw toothed grain beetle) and *Acarus siro* L. (flour mite)].

The insects and mites found in stored cereals include those which tunnel in the endosperm [for example *Sitophilus granarius* (L.) (grain weevil) and *Sitophilus oryzae* (L.) (rice weevil)], those which consume the germ [for example *Cryptolestes ferrugineus* (Steph.) (rust red grain beetle), *Plodia interpunctella* (Hübn.) (Indian meal moth) and *Acarus siro* L. (flour mite)], those which attack broken pieces and dust [for example *Tribolium castaneum* (Herbst.) (rust red flour beetle) and *Glycyphagus destructor* (Schr.) (forage mite)], those which live on moulds [for example fungus beetles (Cryptophagidae and Mycetophagidae)], those which are parasites or predators on other insects and mites (for example Braconidae and Cheyletidae) and those which are scavengers on dead bodies of other insects (for example Dermestidae). Many species are capable of performing more than one role [for example *Tenebroides mauritanicus* (L.) (cadelle beetle) is a predator and an occasional feeder on germ].

The principal factors which affect the development and activity of insect and mite pests are

a) the temperature;

b) the moisture content of the grain;

c) the relative humidity of the immediate atmosphere;

d) the nature of the grain.

Most insect pests of stored grain cannot complete the full development from egg to adult, mating and further egg production at temperatures below 10 °C or greater than 35 °C. The minimum temperature required for the multiplication of most of the serious insect pests is about 15 °C and the lower end of the optimum range is at least 20 °C. For most mites, the limits and optima are generally 5 °C lower.

The moisture content of grain affects insects and mites directly, since they absorb water with their food, and indirectly through controlling the relative humidity of the inter-granular air. For each species, there is a minimum relative humidity below which complete development cannot take place or which is lethal. Grain of less than 9 % (m/m) moisture content (equilibrium relative humidity of approximately 30 %) is generally secure from insect or mite attack, although *Trogoderma granarium* Everts (khapra beetle) can breed at a moisture content of 2 % (m/m).

For each species, there is a combination of temperature and humidity at which populations increase most rapidly. This means that different species tend to occur in those parts of the world where the climate is most suitable for them.

A summary of these conditions for the most common species of grain pests is given in annex A.

3.4 Heating of grain caused by insects and mites

Large bulks or bagged stacks of cereals and pulses tend to stabilize the conditions of temperature and humidity within them. It is these conditions, in particular, which directly affect the insects, and not the diurnal fluctuations in the free space of the store. Local variations in the temperature and moisture contents of bulks are exploited by insects and mites which tend, by random movement, to find their way to favourable breeding places. If conditions here are above the minima shown in

annex A, the insects will breed. As they develop they produce heat which may not disperse as rapidly as it is produced. The temperature rises and insect development accelerates. Eventually the temperature rises to an unfavourable level, usually not above 42 °C, and those insects which can move outwards do so: those which cannot (for example larvae within grains) eventually die. The living insects finally concentrate at the surface.

Temperature gradients are established in the bulk, and moisture moves from the hot interior to the cooler periphery. If the temperature at the surface is below the dew point of the moist air from the interior, condensation will take place and the grain may eventually sprout. The moisture content and equilibrium relative humidity may be raised locally to a point at which the growth of moulds is initiated. Thus, in grain nominally safe for indefinite storage, "dry grain heating", initiated by insects, may change to "damp grain heating" caused by micro-organisms. The temperature in "damp grain heating" seldom rises above 62 °C and usually remains at about 52 °C.

3.5 Prevention and control of insect and mite infestation

3.5.1 Prevention

Attack may be prevented by denying access to insects and mites, by maintaining an environment unfavourable for breeding, or by applying a protective treatment to the grain. The principal techniques for prevention are good hygiene, (i.e. the removal of all unwanted grain and dust in which insects and mites can breed), treatment of empty locations, and control of the environment, by such means as

a) keeping grain below the temperature or the humidity necessary for increase in pest numbers (for example by drying, aerated storage, refrigerated storage);

b) hermetic or inert-atmosphere storage;

c) enclosing pest-free grain in insect-resistant containers;

d) addition of insecticides[1] (for example pyrethrins, organophosphorus insecticides) to repel or kill invading insects.

3.5.2 Control

3.5.2.1 General

An overall strategy involving several methods is usually necessary.

Control may include killing or removing insects and mites

a) in empty storage buildings;

b) in empty transport vehicles;

c) in containers (including sacks) before they are filled with grain;

d) in the grain itself.

3.5.2.2 Mechanical and physical methods

Grain may be

a) screened to remove free living insects and mites;

b) treated with inert dusts;

c) heated (but care is needed because there is only a small differential between the temperature needed to kill insects and that at which grain may be damaged);

d) treated with gamma radiation, other high-frequency electromagnetic waves or accelerated electrons;

e) placed in airtight storage, in which insects are killed when they reduce the oxygen content in the atmosphere to below 2 %;

f) placed in an artificially generated controlled atmosphere;

g) aerated to lower its temperature and/or moisture content.

3.5.2.3 Biological methods

There are very few circumstances in which biological control (i.e. the use of predators, parasites or pathogens) is likely to be effective in the control of cereal pests, because the levels of stabilized populations are normally too high to be tolerated. The bacterium *Bacillus thuringiensis* is used commercially for the control of moths in stored wheat, maize, sorghum grain, rough rice and soya beans.

3.5.2.4 Chemical methods

Chemicals are used in two main forms, i.e. contact insecticides and fumigants.

3.5.2.4.1 Contact insecticides

Residual contact insecticides and acaricides — applied as dusts, oil-in-water emulsions or water dispersible sprays, aerosols or smokes — render the surfaces of empty stores, transport vehicles, ships, cargo containers and conveying equipment toxic to insects and mites. When the insects and mites cross these surfaces they pick up sufficient toxic material to kill them before they reach the commodity to be protected. This technique is effective against crawling insects and mites. The period for which the insecticide persists is dependent on the nature of the surface, temperature, moisture content of the air and extent of exposure to light. Flying insects may be killed by the use of aerosols or smokes whilst in flight, or when they

1) References to "insecticides" are intended to include also "acaricides".

alight on a treated surface; flying insects and those on the surface of commodities may also be controlled by volatile insecticides intermediate in properties between contact insecticides and fumigants.

Some insecticides and acaricides may be added to grain as dusts or sprays, but because of the danger to health the number which may be used in this way is limited (see 3.5.2.4.3).

3.5.2.4.2 Fumigants

Control of pest populations deep in the structure of buildings or vehicles, in empty sacks and in the grain itself, whether in bags or bulk, can be achieved only by fumigants, which act as gases, even though they may be applied as solids or liquids, and which normally have no residual effect on insects or mites after the fumigant has dispersed.

Fumigant gases are generally toxic to man and should only be used by properly trained persons, who know the dangers and the necessary safeguards.

3.5.2.4.3 Pesticide residues

In many countries the sale and use of insecticides is regulated by Governments whose requirements keep in mind the possibilities of contamination of any grain to which they may be applied. The recommendations of the FAO/WHO Codex Alimentarius Commission regarding limits for residues in food are taken into account in such regulations. Only those insecticides which are specifically approved in this way should be used in grain stores or mixed with pulses or cereals, and even then they should be used strictly in accordance with the manufacturer's recommendations and any Government requirements in regard to safety in use.

The recommendation of the International Maritime Organization (IMO) regarding the use of pesticides in ships should also be taken into account.

Such use should also take into account the requirements of purchasers (for example some maltsters require for barley a certificate of freedom from malathion) within a country and in other countries.