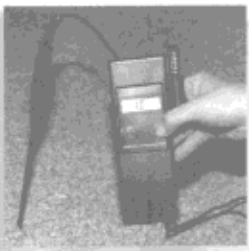
PROTIMETER

CARE OF GRAIN

A guide to professional grainstore management



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CONTENTS

FOREWORD

With the implementation of the NFU Assured Combinable Crops scheme I was pleased to be asked by Protimeter to contribute to the latest edition of their booklet, **Care of Grain.** This publication provides technical advice to farmers and store keepers on good grain storage practice.

Whilst there is renewed emphasis on this subject due to the requirements of Grain Quality Assurance, producers are also under increasing commercial pressure to maximise and maintain quality of product at ever more competitive prices. This booklet offers the farmer concise information on the steps necessary to achieve this.

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[1]Robin Wilkin has been involved with research concerning the storage of grain for many years with the MAFF Central Science Laboratory. He now operates as an independent consultant in this field, with clients across the world. He retains a special interest in the relationship between moisture, temperature and pest development in stored grain. Furthermore, he has a keen interest in developing appropriate sampling and test procedures within the industry.

INTRODUCTION

Grains, and indeed most dry seeds, are stable materials which will keep almost indefinitely without any loss in quality. There should, therefore, be no difficulty in preserving grain between harvests. In practice, this is not as simple as it sounds and cannot be achieved without care, effort, and attention to important detail. Unfortunately, this is not well understood and, as a result, much grain leaves the store in poor condition. A consequence is that it must be sold at a discount or will not meet the specific quality standards for uses such as milling or malting. Even grain kept on farm for stockfeed is at risk. Insufficient care may yield grain that is not fit for direct consumption.

Fortunately, the basic rules are easy to understand and simple to apply in farm and commercial grain stores. This booklet sets out the essential principles and practices of good grain storage, as well providing information on storage strategies. Not surprisingly, it also covers moisture measurement is some detail, including calibration standards and the correct use of moisture meters.

NOTE: Most of the advice is aimed at cereal grains and this will not necessarily apply to oilseeds. There is some specific advice for the storage of oilseed rape given in this booklet and this can be used as basic advice for a range of oilseeds.

CHAPTER 1

The essentials of safe grain storage

There are four requirements that form the basic core of SAFE grain storage:-

1. Grain must be at a suitable moisture content when it goes into store.
2. Temperature gradients in bins or bulks must be evened out.
3. The grain must be protected from the ingress of water and condensation.
4. Grain must be protected from attack by pests (insects, mites, rodents and birds)

Grain may be dry enough for storage when it is harvested, but this is often not the case and it may be necessary to dry grain artificially prior to storage. To dry or not to dry is the first key decision and getting it right will influence success of the rest of the storage season as well as the costs of storage. However, you cannot make a decision without the knowledge of what a safe moisture content is, the specific requirements of your intended market and a means of measuring the moisture content.

WHAT IS A "SAFE" MOISTURE CONTENT ?

The answer is not simple or clear because it depends on a number of factors including:

a) Length of storage period
b) Likely grain temperature during storage and the rate at which it can be cooled.
c) The amount of damage to the grains.
d) The intended market.

Period of storage: if grain is to be stored for only two or three weeks it is just about possible to have moistures in the range of 16-18%. However, few if any markets will accept grain at this moisture content. If the storage period is to be extended further, the only safe recommendation is to store at a maximum moisture in the range 15 - 16%. Even these levels will only allow safe storage if firm action is taken to ensure that the temperature in the bulk of grain is below 15 °C and temperature gradients are evened out. These recommendations are set out in detail in Table 1.

The effect of temperature: this is very important and is dealt with in more detail in Chapter 2.

Damage to grain: if the individual kernels of grain are undamaged, they are far more resistant to attack by pests or moulds. When grain is harvested using a combine, some damage is inevitable and the degree is affected by the setting of the concave and by the moisture content of grain in the field. Samples should be checked regularly for broken grains during combining and settings adjusted to give the best compromise between the amount of grain lost in the straw and the numbers of damaged kernels. This procedure will also maximise the quality and marketability of the grain. If many grains are broken exposing the endosperm, it will be necessary to dry the grain by an additional 1%. It must be

remembered that harvested grains do not develop a protective layer over broken surfaces as with potato tubers.

Intended market: if grain is sold off-farm, the maximum moisture that is generally accepted without penalty is 15% cereals and 9% oilseeds. ISO 712 oventest (130°C/2hrs) not to be confused with the old UK oventest (105°C/4hrs) now superceded. Some older moisture meters in use may well be calibrated to the UK standard. If in doubt, it will pay to have your meter checked and recalibrated. Exceeding this will result in rejection or a reduced price. Many markets apply lower limits for moisture such as milling (usually 14.5%), exports (15%) and intervention (14.5%). There is little sense in storing grain above the maximum moisture content of the intended market, so drying should be done directly after harvesting and prior to long term storage.

Table I

Table of Recommended Maximum Safe Moisture Contents for Storage of Grain for the Periods Shown

Temperature

Moisture Content: Stored	0°C / 32°F	5°C / 41°F	10°C / 50°F	15°C / 60°F	20°C / 68°F	25°C / 77°F	30°C / 86°F
To November	26%	24%	20%	17%	14%	Unlikely to be as hot as this	
To end of the year	24%	22%	18%	15%	13½%	13%	
To March	23%	21%	16½%	14%	13%	13%	
To May	Not practicable to keep grain as cool as this without special refrigeration after March		16%	14%	13%	12½%	12%
To July				14%	12½%	12%	11%
Through a second winter to the following summer				12½%	12%	11%	10%

Fig 1.

Notes:

1. The temperatures are for bulk grain temperatures, not the air temperature within the store.

2. Low volume ventilation will be able to reduce grain temperature below 10°C by November and this will be maintained well into the following summer.

3. Although a temperature of 25°C or 30°C is described as unlikely in the Table, grain fresh from a drier will be this hot. Therefore, such grain must be cooled using low volume ventilation as soon as possible. A less effective alternative if ventilation is unavailable, is to turn the grain regularly.

The importance of correct storage moisture and temperature

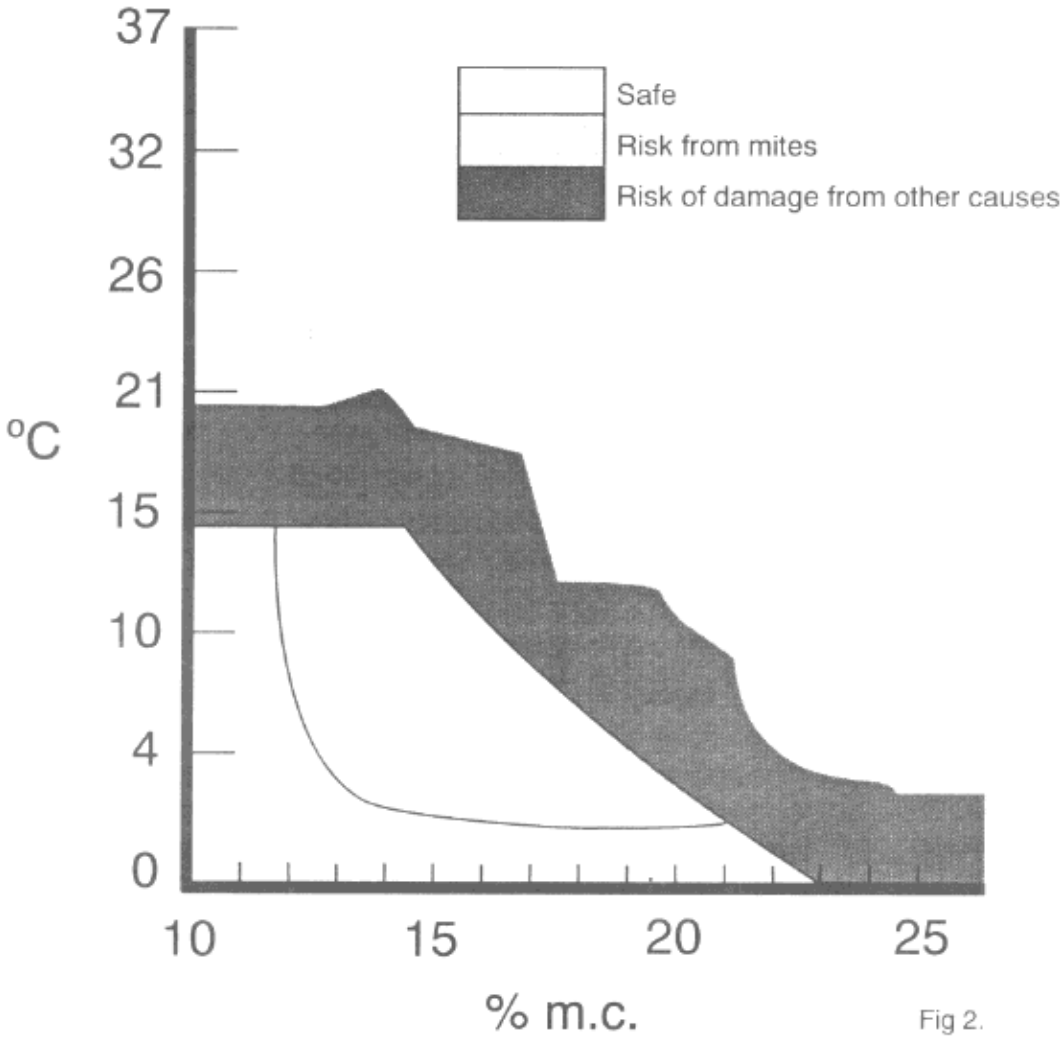


Fig 2.

courtesy of MAFF

CHAPTER 2

The importance of temperature

The temperature of grain affects the relative humidity in the spaces between kernels. This means that as the temperature rises, the water in the grains becomes more available to mites and moulds. In simplest terms: COOLING=DRYING.

The temperature of the grain will also control the ability of pests to breed. Below about 18°C, only one grain insect pest can breed and below 12°C, no insects can breed and damage the grain. However, at 27°C several key pests will increase by 10x/month.

To a limited extent coolness is an alternative to dryness, especially for short term storage (say 3 - 4 months), but it is never a complete alternative. Really damp grain will spoil however much care is taken to keep it cool.

Correspondingly, warmth aggravates storage problems and hastens spoilage. In particular, convection currents of air will develop in warm grain and these will carry moisture from the bottom to the top. At the top, the moisture in the warm, damp air will condense in the cool surface layers, which will lead to mould growth and sprouting.

The effects of various combinations of temperature and moisture on the safe storage potential of grain are shown on the previous page.
NOTE: The lower temperature is on the limit for mite development but it may be difficult to maintain this temperature in the surface layers of grain. Hence, localised but serious mite problems can still occur.

Importance of low temperatures

Fig 2. illustrates the value of keeping grain as cool as possible. This is why ventilation with ambient air is so popular. However, the problem is compounded by the heat produced by mould, insects and mites developing within grain. Once any sort of biodeterioration begins, heat and water are the key by-products so that grain becomes warmer and wetter, and the whole process accelerates.

Therefore, the first aim for safe and effective storage is to ensure that problems cannot occur. This is achieved by making the right decision about the moisture content at the start of storage and then by cooling and monitoring the grain throughout the storage period.

Ventilation

Ventilation or low-volume aeration using ambient air checks temperature rise and so prevents the acceleration of spoilage. If cooling is done soon after harvest, most of the serious risks of quality loss during storage can be eliminated and therefore, any need for pesticides will be minimised. This process is the most important component in a safe and cost effective storage strategy. The equipment needed (ducts under the grain and low-power fans) is relatively inexpensive and the running costs are low. The aim is to move 10 cu. m of air/

tonne/hour through the grain. This is the optimum rate for cooling and can be achieved with very small, low-powered fans. Cooling is most effective if night-time air is used, offering further cost saving if off-peak electricity is used to power the fans.

For best results, cooling should start immediately the store is filled after harvest. Even in August, night time air temperatures will fall to 15°C and this offers the potential to reduce grain temperatures sufficiently to minimise any immediate problems.

Warm grain into store

Grain is usually warm or even hot when it goes into store. Even the best driers with effective cooling sections will output relatively hot grain (when used at harvest time.) Undried grain is subject to solar heating in the field and will often come from the combine at temperatures of 25°C or more. Natural cooling in even 20-tonne bulks is very slow, allowing ample time for moisture migration, sprouting and mould growth, as well as offering an ideal environment for insects.

It cannot be stressed too highly that trying to store grain at temperatures above 20°C for any period of time is difficult and increases the likelihood that pesticides will have to be used. Key temperatures are listed below:

25°C All insect and mite pests develop rapidly. Speedy mould growth possible Biodeterioration will be rapid, leading to temperature rise and loss of quality.

15°C Most insect pests cannot breed. Moderate mould growth possible Mite infestations will continue to increase at a high rate.

10°C No insects can breed. Mould and mite development slowed but not stopped.

5°C Mite breeding virtually stopped. Insects will eventually die at this temperature. Very limited potential for mould growth.

As can be seen from the preceding chapters, GRAIN moisture content (MC) and GRAIN TEMP hold the key to safe storage. Therefore, measurement of these two factors is very important, as is a proper understanding of the results.

CHAPTER 3

MONITORING GRAIN DURING STORAGE

Why monitor grain?

Grain is a living organism and will become active even when stored, in certain conditions. Such development will in extreme conditions show up as a "lawn" on the surface of a bulk. However, less obvious symptoms will include an increase in temperature and moisture content. Even if the grain kernels do not develop, other influences can occur during storage which will have an adverse effect on the quality of grain. Mites, mould and insects may start to develop in grain and, if left unchecked, large tonnages of grain can be destroyed or, at the very least, grain will be rejected by a discerning buyer.

The only way to guard against damage and loss during storage is to monitor. Unfortunately, some storekeepers still feel that once the store is full, no further action is needed. Such an approach invites disaster. All forms of biodeterioration can occur with alarming speed. For example, an almost undetectable infestation of grain weevils can multiply at such a rate that the grain will be virtually destroyed after 3 months.

There are three key factors that need to be assessed during storage: pests, temperature and moisture.

Monitoring pest problems

A whole range of insects and mite pests can occur in grain during storage. They are very widely distributed so that all grain must be considered at risk. The level of risk increases if the store has a history of infestation or if it receives grain from multiple sources. **It is therefore important to carry out a thorough pre-season store cleaning and maintenance programme.**

It is possible to markedly reduce the risks from mites by reducing and maintaining moisture contents to below about 14.5%. This approach will also help alleviate the development of mould. Cooling grain to below 12 - 15°C will stop insects breeding and therefore further assist to protect grain during storage. However, even if grain enters the store in a "safe" condition, it is very difficult to ensure that they are maintained throughout several months of storage. Therefore, monitoring is the only option if all pest problems are to be avoided.

Monitoring for pests can take two forms: the collection and examination of samples or the use of pest traps.

Sampling involves collection samples of grain from a range of positions, sieving the grain over a 2mm mesh and examining the sievings for live insects. This sampling should be done regularly (weekly or monthly, depending on the conditions) although it can be directed towards spots most at risk: the warmest areas of grain. It must be borne in mind that the

discovery of even a single pest insect in a sample must be considered as an indication of a serious problem. Finally, there are also many different species of insect found in grain and not all of these are pests. Therefore, expert advice is often warranted when deciding on the importance of an insect discovered in grain.

Mites can also be monitored by the collection and examination of samples, although a smaller mesh of sieve should be used (0.75mm). Mites only develop in grain if the moisture content is above about 14.5%, so sampling should be directed to the areas with the highest moisture content.

Trapping for pests is generally considered to be greatly superior to almost all sampling methods. There are a range of commercial pest traps available and these should be used in accordance with the manufacturer's instructions. They reduce the work-load involved in monitoring and are far more sensitive than the collection of samples. Traps should be inserted into grain, left for about 7 days and then examined. Unlike the assessment of samples, finding a few insects in traps is merely an early indicator of a developing problem and does not necessarily require immediate control action.

Monitoring temperature in grain

It is the temperature below the surface of a bulk that is important as the surface layer will be influenced by changes in ambient conditions. Therefore, it is essential to be able to measure temperatures 1 or 2m below the surface.

Equipment for measuring grain temperatures

An ordinary thermometer is too short and must, therefore, be fixed to a pole so that it can be pushed down into the grain. Even then, it offers a poor system of collecting information about grain temperatures. Firstly, it will tend to change its reading as it is pulled out from the grain. Secondly, inserting a glass and mercury thermometer into grain offers a serious risk of contamination if breakage occurs.

A much better approach is to use an "electronic" thermometer attached to a 1 or 2m probe. This can be read without being pulled out of the grain and responds quickly. Another virtue of the portable electronic thermometer is that it can be used for a wide variety of temperature measuring jobs including air temperatures (for ventilation or bin or floor-drying plants), soil temperatures (for date of sowing or fertiliser applications), and temperature in barn-dried hay or in stored bulk feed. The facility of an electronic thermometer is often included with a moisture meter.

Larger stores (2,000 tonnes or more) will often benefit from having permanent, remote reading temperature probes installed. However, having the correct equipment is only the start: making proper use of temperature recording is the crux of the matter and this is dealt with in the next section.

The proper approach to temperature measurement

Once grain is in store, a single, spot reading gives little information about condition or the need for further action on the part of the storekeeper. However, if regular readings from the same points are taken on a weekly basis , noted down and compared, a clear picture will emerge on the condition of the grain and the risks during further storage. Graphing the temperature readings provides an easily interpreted visual assessment.

Grain is a poor conductor of heat so that in large bulks readings of temperature must be taken at a regular series of points. For large floor stores, measurement points should be spaced on a 4m grid and each point marked with a cane or (similar) marker. A single position in the centre is adequate for small bins (20 - 50 tonnes). If possible temperatures should be taken at several depths at each point (0.5, 1 and 2 m). However, if the aeration system can be used to aerate the grain in an upwards direction for a few minutes prior to measurement, any heating deeper in the bulk will be moved towards the surface.

Regular temperature measurement should show that the temperature of the bulk falls from the bottom up, as cooling proceeds. Uneven cooling across the bulk may be the first signs of a fault, such as a blocked duct, with the aeration system. Once a safe temperature has been achieved (5 - 15°C, depending on the storage period), it should hold this temperature throughout the winter and spring. Any increase in temperature of more than 2°C/week must be investigated as it is likely to be an early indication of some storage problem.

Monitoring moisture during storage

It is important to monitor the moisture content of grain during storage as changes, except in the surface layers, are a sure indicator of possible problems. The best approach is to check the moisture content of the samples collected during pest monitoring, record and compare the results. At depths of 0.5m or more, the moisture content should not change by more than 0.5%. The surface layers will change in relation to ambient moisture but monitoring these changes can provide an early warning of potential problems with mites.

Moisture measurement is discussed in more detail in Chapter 5.

CHAPTER 4

Points to note during drying

When grain is harvested, the moisture content should be checked at the earliest stage. Checking samples ex-combine is an excellent policy. This information, coupled with the requirements of the likely market, can be used to assess the need for drying. As explained earlier, any drying that is needed is best done at the start of storage rather than at a later stage. The exception to this is if the grain is stored on a drying floor or in a drying bin. Even so, it is usually more effective and economical to dry during the early autumn than later in the year.

This booklet is not a comprehensive guide to grain drying and the manufacturers' instructions must be closely followed when using the various types of continuous flow or batch driers. In particular, care must be taken not to exceed the maximum recommended temperature of the drying air. This will vary according to the moisture content of the grain, the amount of moisture to be removed and the type of cereal. IT IS ESSENTIAL TO HAVE RELIABLE READINGS OF THE GRAIN MOISTURE CONTENT BEFORE AND AFTER DRYING IF SAFE AND COST-EFFECTIVE DRYING IS TO BE ACHIEVED. Hence, a good moisture meter is an essential accessory to a drier.

When using a hot air, rapid drier, multiple samples of incoming grain must be tested for moisture so that the average and range of moisture can be established. Work out the amount of water to be removed and then consult the drier manufacturer's instructions regarding the temperature settings and through-put needed to achieve the desired final moisture content. During drying, take regular samples, check for moisture content and make any small adjustments to the drier settings as needed. Remember that many moisture meters do not have effective temperature compensation so that the results with the hot grain ex-drier may not be reliable or may require adjustment.

Once grain leaves the drier and goes into store, it should be ventilated or aerated to even out temperature gradients and start the cooling process.

On-floor drying also requires careful monitoring of moisture but the process is much slower. Once again, the advice of the manufacturer must be followed. These systems work on the basis of the relative humidity of the in-going air being lower than the equilibrium relative humidity of the grain, so the actual temperature is less important. However, adding too much heat in an effort to speed drying is likely to be counter-productive as this will merely overdry the bottom of the bulk. The best way to monitor the performance of an on-floor drying system is to collect samples from specific points and depths at regular intervals and test the moisture content.

LOSS OF WEIGHT

The loss of weight produced by drying is a source of confusion to many. The percentage of moisture in grain is calculated on the weight of grain including its moisture. Therefore, the loss of weight is always greater than the difference in percentage moisture content. Table 2 shows the actual out-turn as a result of drying by a certain percentage. It will be seen, for example, that if 100 tonnes of grain at 28% moisture content is dried to 18% the product will be 87.75 tonnes, a loss of 12.25%, not 10%.

Table 2 Out-turn in Kg. From 1000 Kg before drying.

		Original Moisture Content					
		18%	20%	22%	24%	26%	28%
Moisture Content After Drying	18%	1000	976	951	927	903	878
	16%	976	953	929	905	881	857
	14%	954	930	907	884	861	837
	12%	932	909	887	864	841	818

CHAPTER 5

Measuring moisture content

The importance of moisture content is threefold:

- It is one of the key factors which controls the keeping qualities of the grain.
- The weight of grain is affected by its moisture content.
- The moisture content may be fixed by the buyer. Exceeding the contractual level will result in a penalty.

Measuring the moisture content of grain is, on the face of it, a simple process. However, every season there are disputes between buyers and sellers about grain moisture content. Usually, these problems relate to the buyer finding that his assessment of the moisture content is above the contractual limit. Hence the grain is rejected, or accepted at a discount. The seller, on the other hand, is sure that the moisture content is below the specified maximum.

Surprisingly, both parties may be correct, at least in part. Errors in sampling and/or the measurement of moisture account for most of these disputes and it is essential that the basic points are understood.

1. SAMPLING *(see also BS 4510 - ISO 950)*

One of the greatest limitations to accurate assessment of grain quality is inadequate sampling. A single sample from a lorry-load of grain can give a moisture content which is 1 or 2% different from the mean value. Fortunately, this problem can be overcome by collecting several samples from different points and depths in the load, mixing these together and measuring the moisture of a sub-sample of the mixed batch. Even more information can be collected if the individual samples are assessed separately. This will provide data on the range and variation of moisture within the load and can be used to predict the number of samples needed to achieve a specified level of error.

Accurate sampling of bulk or lorry-loads of grain depends, in part, on common sense, although the safety of the operator must always be paramount. However, there are a number of conventions for grain sampling which are used by the industry. The most commonly used is: BS 54510:1980 which stipulates the number of samples and the positions from which they should be taken, according to the situation. If the buyer of grain uses the BS method or stipulates its use in the contract, then the seller should ensure that he employs this method.

In practice, it has been shown that exact adherence to the BS method is not essential and, provided sufficient samples are taken, the exact location of the sampling points can be flexible. This pragmatic view is supported by some recent research findings.

The following is an extract, reprinted by kind permission, from ***Integrated Grain Storage Manager,*** a software program developed by the Central Science Laboratory in conjunction with MAFF and HGCA. The program covers all aspects of grain storage and the records section enables users to input their store and storage data then print out quality assurance reports directly for ACCS and SQC audit trails. Further details available from: Imperial College of Science Technology and Medicine, Silwood Park, Ascot, Berkshire SL5 7PY.

Sampling Grain

Safety

Sampling grain can place operators in dangerous situations. Therefore, operator safety must be the overriding consideration. There are four main risks:

1. Exposure to grain dust.

This represents a serious hazard to health and proper protective masks must be worn whenever operators are required to work in the presence of dust. Collection and assessment of samples will inevitably create dust.

2. Danger of falling.

Access to positions from which bins, bulks or lorry-loads of grain can be sampled, may place operators at risk of falls. All access must be via safe, protected routes.

3. Danger of engulfment.

Grain, particularly in bins, may bridge during emptying, creating voids beneath the surface. Walking on the surface of grain can causes these bridges to collapse, leading to the engulfment and suffocation of the worker. Never walk on the surface of grain in a bin as it is being emptied, or if there is any risk that bridging may have occurred.

4. Danger from toxic gases.

Grain can generate carbon dioxide during storage and may also metabolise oxygen. In enclosed spaces, this can result in a lethal atmosphere that will cause loss of consciousness, followed by death in less than a minute. Never, enter a partly filled bin or store unless you are certain that it is safe to do so. Be aware of the risks and have emergency procedures in place.

Requirements of sampling

Sampling is done to determine the quality of a specific parcel of grain or to assess its suitability for continued storage. Sampling methods will depend upon why the grain is being sampled and its location. Pest detection may also be done by collecting and examining samples but this can require a slightly different approach.

When sampling to determine quality the aim is to obtain a representative sample. This will often require the collection of multiple sub-samples from many different parts of the batch

of grain. The method of collecting these samples can influence the sample and, therefore, the results of any quality determination. An important feature with pest detection is the amount of grain that is examined: the bigger the sample, the greater the chance of detection. However, collection of samples for pest detection can often be concentrated on those parts of the bulk most likely to harbour pests (warmest or wettest areas).

Determination of grain quality

1. General details

There are a wide range of quality parameters that may be applied to different types of grain (see Quality Standards). These parameters may require different sampling techniques and some can change during storage or even during the loading of a lorry. For example moisture content may change during storage and the distribution of fine material can change as a lorry is loaded.

These notes are intended to cover sampling grain as a general commodity. Sampling seed and feed grain may be covered by separate, statutory regulations and some contracts may specify methods of collecting samples.

2. Sampling lorry loads of grain

ISO 950 is a widely recognised International Standard method for the collection of samples from grain and it is particularly suitable for lorry sampling. The method offers guidance for sampling and can be used as the basis of any alternative approaches but there is no scientific basis to the Standard. However, it is recognised and used by the Intervention Board, so that any alternative needs to provide a sample comparable to that given by IS 950. One constraint to the IS method is that it may require a man to walk on the top of a lorry-load to collect samples. This has serious safety implications and may contravene HSE Directives and Guidelines.

For large concerns, an effective and safe approach is to use an automatic probe to collect samples. This can often be programmed to collect core samples (a core of grain taken from the top to the bottom of the load) to a set and repeatable pattern. At least 6 core samples should be collected from different positions in a 20 - 25 tonne load. UK research has shown that with wheat and barley, the precise location of the sampling points is not important. This system will give a mean value for quality that is not significantly different from that produced by using the IS 950 method. The sample positions given by IS 950 for a 25 tonne load are as shown below:

The six core samples can be mixed and then divided down to give a working sample that is used for quality assessment. However, if the samples are assessed individually on a number of occasions, this will give far more detailed information about the variation in

quality within and between loads. Given suitable statistical tests, results from individual samples can be used to predict the numbers of samples needed in future and the probability of quality assessment being accurate.

There are two possible alternative manual methods of assessing the quality of loads of grain in lorries without having to go on top of the load to collect samples. The grain can be sampled as it is loaded into the lorry or as it is being discharged. There is little data on sampling lorries during loading but American work suggests that collecting 6-1kg samples from the tail gate of a lorry during tipping will give a sample that can be used to estimate most quality parameters. However, these samples must be collected with a Pelican type of sampler as research suggests that a simple scoop will overestimate the amount of fine material in the load.

3. Sampling bulk grain for quality.

It is extremely difficult to collect a representative sample from stored grain unless it is held in a small bin. Generally, it is impossible to collect samples from all parts of a bulk and, if the grain is deeper than 3m, large parts of the bulk may remain un-sampled. Therefore, it is always better to collect samples from loads of grain as the store is filled and use these to assess the grain quality.

If the only option is to sample during storage, the ISO 950 system should be followed. This requires the grain to be sampled using hand spears or a portable vacuum sampler and samples collected at the rate of about 10 samples, with a total weight of 5kg, per 100 tonnes. Samples must be taken at different depths as well as different positions. This would indicate that 100 samples with a total weight of 50kg must be collected from 1000 tonne bulk. In practice, sampling rates are often lower and, therefore, the samples may not be representative. The problem is compounded because it is difficult to collect samples at depths greater than 2m with hand spears. If moisture and mites are being monitored, it is essential that samples are collected from the surface layers of grain as well as at depths. The moisture content of surface layers will often change as a results of adsorbing or desorbing water to the atmosphere. Also mite infestations often start in the surface layers of grain.

Grain in small bins can be sampled effectively during storage because the spear can reach all parts. However, the only method for very deep silos is to turn the grain and collect samples from the flow.

4. Sampling moving grain:

The collection of samples from conveyors can be dangerous and may contravene Health and Safety at Work regulations. However, if samples are collected without endangering staff, they can provide an accurate assessment of grain quality. One way of collecting samples safely is use a diverter sampler.

Samples should be collected at the rate of about 1kg/20 tonnes and each sample assessed individually. The results can be combined to give mean values, together with maximums and minimums. These will provide a good assessment of the overall quality of a grain bulk.

With larger, flat stores , the surface should be divided into 3m squares and the corners of these squares used as sample points. Each point should be marked and samples collected from the surface and at 1m. If the grain is more than 4m deep, further samples should be collected at a depth of 2m. Once a bulk has been sampled in this way, the quality parameters should not change with time. However, temperature, moisture and pest levels can change during storage so that regular assessment in an essential part of store management. In large bulks, it may be acceptable to asses the sample points on a rolling basis as long as each point is sampled at least every 4 weeks.

Detection of pests

Almost all grain is at risk from infestation. Insect and mite pest are widely distributed in both farm and commercial grain stores. MAFF data shows that, at any one time, 10% of farms stores and 30% of commercial stores will have some insect pests. Mites are much more widely distributed. Therefore, when receiving grain from several suppliers, there is a high risk that some loads will be infested. All the grain pests are relatively small (less than 4mm) and they shun light, which makes them difficult to detect. Once a few pests become establish in a grain store they can increase in numbers and also they can persist in the store between seasons.

Unfortunately, the distribution of insects in grain is likely to be random but clumped. Therefore, detection by the collection and examination of samples is difficult and the results are dependent on the amount of grain that is examined in the samples. It is very important to remember that not finding insects in a sample does NOT mean that the grain is uninfested. It may just mean that the level of pests was below the threshold of detection of your method. Reliable detection of insects at 1/kg requires sampling at the rate of 25kg/100tonnes.

1. Detecting pests in store

When grain is in a store, sampling should be targeted towards the areas of highest risk: the warmest grain for insects and the wettest grain for mites. It is much better to use traps to detect insects than to rely on the collection of samples. However, if sampling is being used, the first step should be to record temperatures in the grain. If all grain temperatures are below 10°C, serious problems with insects are unlikely. However, any areas with higher temperatures or where the temperature is increasing week by week, must be sampled. Collect at least 10X500g samples in a close group around the warmest areas. Sieve each sample over a 2mm mesh and examine the sievings for insects. If insects are found they should be identified and then the GPA model MUST BE RUN to check on the extent of the problem.

Mite problems are most likely in grain with a moisture content of more than 15%. Therefore, assess the moisture distribution in the bulk and then concentrate the inspection on the wettest areas. Mite problems often start in the surface layers so collecting scoops of grain from the surface is an acceptable method of sampling. Sieve the samples over a 1mm mesh and examine the sievings for mites. A x10 hand lens and a good light are needed for this. When checking for mites, samples must be examined quickly as the mechanical damage caused by sampling can kill many mites. Also, samples should not be collected with a vacuum sampler as this will destroy the mites.

Commercial insect traps offer the most effective method of detecting pests in bulk grain. These traps should be placed at the sample points suggested in the above instructions and examined on a weekly basis. See monitoring pests for advice on trapping and the interpretation of trap catch results.

2. Detecting insects in lorry loads of grain

Most conventional pest detection methods use samples of half to one kg of grain and these samples will be taken from a minimum lot of twenty tonnes and sometimes much more. If a single insect is detected in a sample using this type of approach, it probably means that the infestation level is between 2 and 5 insects per kg in the load or lot. If no insects are found, the grain may still contain 1 or 2 insects/kg.

The key rule to detecting insects in grain during transit is: the more grain that is examined the better. If it is very important that the grain is free from insects, at least 10kg, collected from several different places, should be examined from each lorry or per 20-25 tonne load.

When any insects or mites are found, proper identification is essential. Use the key and the pest portraits in GPA to assist in identification. If you are unsure, seek expert advice.

There are a wide range of quality parameters that may be applied to different types of grain (see Quality Standards). These parameters may require different sampling techniques and some can change during storage or even during the loading of a lorry. For example moisture content may change during storage and the distribution of fine material can change as a lorry is loaded.

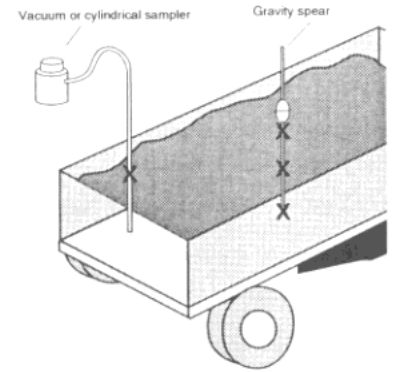
These notes are intended to cover sampling grain as a general commodity. Sampling seed and feed grain may be covered by separate, statutory regulations and some contracts may specify methods of collecting samples.

2. Sampling lorry-loads of grain

ISO 950 is a widely recognised International Standard method for the collection of samples from grain and it is particularly suitable for lorry sampling. The method offers guidance for sampling and can be used as the basis of any alternative approaches but there is no scientific

basis to the Standard. However, it is recognised and used by the Intervention Board, so that any alternative needs to provide a sample comparable to that given by ISO 950. One constraint to the ISO method is that it may require a man to walk on the top of a lorry-load to collect samples. This has serious safety implications and may contravene HSE Directives and Guidelines.

For large concerns, an effective and safe approach is to use an automatic probe to collect samples. This can often be programmed to collect core samples (a core of grain taken from the top to the bottom of the load) to a set and repeatable pattern. At least 6 core samples should be collected from different positions in a 20 - 25 tonne load. UK research has shown that with wheat and barley, the precise location of the sampling points is not important. This system will give a mean value for quality that is not significantly different from that produced by using the ISO 950 method. The sample positions given by ISO 950 for a 25 tonne load are as shown below.



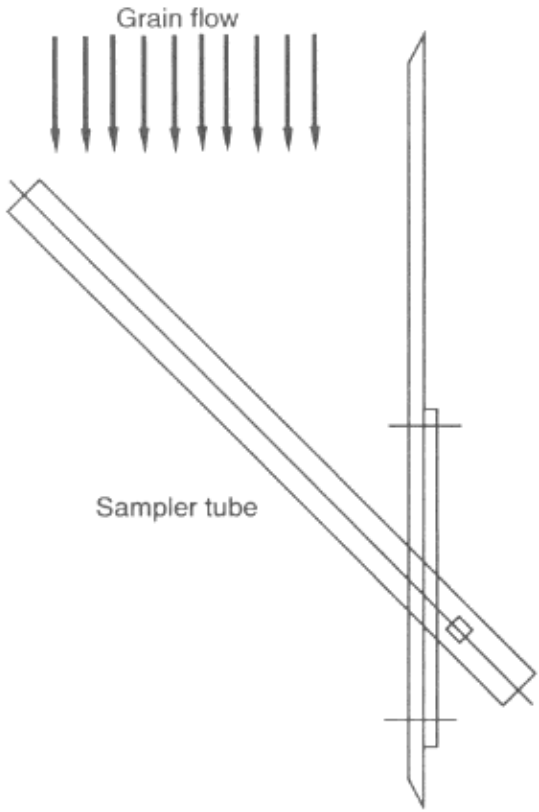
Up to 15 tonnes

Over 15 tonnes

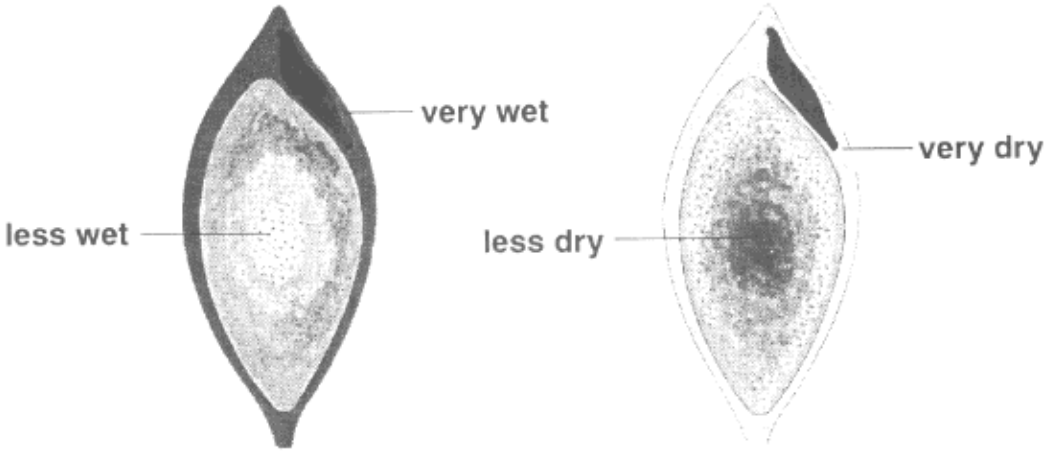
The six core samples can be mixed and then divided down to give a working sample that is used for quality assessment. However, if the samples are assessed individually on a number of occasions, this will give far more detailed information about the variation in quality within and between loads. Given suitable statistical tests, results from individual samples can be used to predict the numbers of samples needed in future and the probability of quality assessment being accurate.

4. Sampling moving grain:

The collection of samples from conveyors can be dangerous and may contravene Health and Safety at Work regulations. However, if samples are collected without endangering staff, they can provide an accurate assessment of grain quality. One way of collecting samples safely is use a diverter sampler.



Samples should be collected at the rate of about 1kg/20 tonnes and each sample assessed individually. The results can be combined to give mean values, together with maximums and minimums.



2. MOISTURE MEASUREMENT

Moisture in grain is present in several forms and different approaches to measurement will make different assessments of these forms. Also some methods of measuring moisture inadvertently confuse other, non-water volatile components and may over estimate the moisture content. As a result, few if any methods of measurement make an absolute measurement of the amount of water in grain and using different methods may give different results.

In practice, these differences are usually relatively small but they do add to problems of measurement. This starts with the Standard Method used as a norm and to calibrate moisture meters. Generally, Standard Methods are based on drying a sample of grain in an oven and calculating the moisture content on the basis of weight loss.

Oven Tests: in practice a ground and accurately weighed sample is dried for a specific time in a specially designed, ventilated hot air oven at a controlled temperature. After cooling in a dry atmosphere, the sample is re-weighed. The loss in weight due to evaporation of water is expressed as a percentage of the original weight and this gives the moisture content. The time and temperature combination will affect the weight loss and also the apparent moisture content of the sample.

PROBLEMS CAUSED BY DIFFERENT STANDARDS

Different "Standard" oven methods give different BUT NOT WRONG answers for the same sample. The "correct" method is usually specified by Trade or Industry bodies involved in the purchase or processing of grain. In some cases the Standard may be specified by Government regulation in the case of international trade or sales into intervention.

The range of "correct" moistures determined by different "Standard "oven methods can vary by as much as 2%, for example from 13% by one method to 15% for another. Yet each method is "correct" for the trade or country which uses it.

U.K. OVEN STANDARDS

Three standards are currently in use in the UK. Most commonly, the ISO 712 method is specified. This covers milling wheat, feed grain, export sales and the intervention market. This requires a very fine grind and a temperature of 130°C for 2 hours timed from when the oven regains its temperature after the sample is inserted. The method is also widely accepted throughout Europe.

For malting barley, the Institute of Brewers (IOB) specify that either the ISO method or their own method should be used. The IOB method uses a temperature of 105 - 106°C for 3 hours plus 1 hour.

The Fertilisers and Feeding Stuffs regulation specify that a coarsely ground (or kibbled) sample should be dried for 4 hours at 105°C.

The ISO 712 method will always give a reading higher by about 0.5% than the other two UK Standard methods.

RAPID METHODS

As oven tests take several hours, rapid methods are often used in practice. Normally these use an electrical meter to measure the resistance or capacitance of a grain sample. (Other so called rapid methods exist which shorten and simplify the oven drying method referred to earlier.) These are no more accurate than electrical meters but are always slower and less convenient. Whatever system is used, the measurement must be made on a sample so that the accuracy can never be better than the sampling error. This is the great fault also, of course, applies to Standard oven methods. Indeed the problem may be worse with oven tests as their complexity discourages checking multiple samples. Fortunately, the rapid electric moisture meter encourages the assessment of multiple samples.

CALIBRATION OF MOISTURE METERS

Moisture meters do not measure moisture in grain directly, but some characteristic such as capacitance or resistance, that is related to moisture. Therefore, all meters must be calibrated using a range of samples and a "Standard" method. Obviously, the Standard to which a meter is calibrated is very important as it will effect the results obtained. It should always be stated clearly to which Standard any meter corresponds.

Some moisture meters imported from Europe and used by merchants and processors are calibrated against the ISO method. Some meters from the U.S.A. are calibrated to the US Standard method and these can be expected to give different results.

Make sure that you know the Standard method against which your meter is calibrated. The best compromise is to have a meter calibrated against the BS or ISO Standard method. Even so, it is still worthwhile checking the Standard used by the buyer and even doing some comparative tests. The seller can then compare his meter readings on several samples with those of the buyer, note the difference and, if necessary, apply a correction to his readings in order to make them agree with those of the buyer.

One very important point with regard to moisture meters is that like any other piece of complex equipment, they will perform best if given a regular service by the manufacturer. It is recommended that meters are returned for service and re-calibration on a regular basis. At least in this way there will be no confusion about the Standard method used to calibrate the meter!

MOISTURE METERS AND WHY GRINDING IS ADVANTAGEOUS

When moisture meters are used during or immediately after the harvest, the outside husk of the grain is not at the same moisture level as the inside. This is still true immediately after high temperature drying. Indeed, it will take several weeks or even months before an equilibrium is reached. Therefore, moisture measurements which are heavily influenced by the husk will be unreliable.

If the sample is ground, the husk fragmented and the endosperm exposed, the assessment of moisture will be more accurate. If this is combined with compressing the sample to a constant pressure, a reliable and repeatable reading will result.

Equipment List

For proper safe and cost effective storage certain equipment is essential. The investment in growing and harvesting the crop is large but much of the benefit can be thrown away by a little inattention during storage. Remember, once grain is damaged during storage, nothing can be done to recover the lost quality. Therefore, all efforts during storage must be directed towards eliminating problems or at least detecting them at an early stage before irreparable damage is done.

The following equipment will assist a storekeeper to monitor grain and make the correct decisions regarding storage and marketing.

- Grain sampling probe (2m, compartmented spear)
- Nest of sieves (2mm + 0.75mm mesh)
- Moisture meter (calibrated to ISO 712)
- Temperature probe
- Insect traps

In addition, the storekeeper should have a clear plan for storage and the ultimate market for his grain.

SUMMARY

Key pointers to cost-effective storage:

1) Plan ahead and have a clear idea about the intended market for the grain
2) Check the moisture content during combining. Decide if drying is needed.
3) Check the moisture content regularly as the store is filled. Make sure ALL the grain is dry enough for safe storage and to meet any contractual requirements.
4) Once the store is filled, cool the grain with aeration using night-time air. Aim to cool below 15°C as quickly as possible and then, as the nights become cooler, reduce temperatures below 10°C . If the grain is very dry, care will be needed to avoid re-wetting during aeration, so a check on relative humidity can pay dividends.
5) Monitor the temperature and moisture content regular during storage. Record the information and check for unexplained changes.
6) Monitor for pests by using traps and sieving samples.

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