



# Wheat and Flour Testing Methods:

A Guide to Understanding Wheat  
and Flour Quality: Version 2

# Acknowledgements

Wheat and Flour Testing Methods: A Guide to Understanding Wheat and Flour Quality Version 2 provides an introduction to the analysis of wheat and flour in a clear and concise format. Basic information is presented on standardized testing procedures for wheat and flour quality characteristics as well as dough properties. Results from these tests are explained and applied to processing performance and product quality. Laboratory testing of a variety of wheat-based finished products is also included. The finished product formulations and processes described are laboratory testing protocols that are used to evaluate flour quality. They are model systems that may be used to predict commercial production for common uses of wheat flour worldwide.

This publication is the result of a USDA Market Access Program grant made available to the International Grains Program at Kansas State University, in cooperation with the Wheat Marketing Center, Inc. and the Northern Crops Institute by the Market Access Program (MAP) Committee of the North American Export Grain Association (NAEGA).

Writing and producing this site is a joint project with many people contributing.

- David Shelton, Executive Director, of the Wheat Marketing Center, Inc. for the vision of writing and coordinating the book from which this website developed.
- Gary Martin, President and CEO of NAEGA for providing direction and arranging financial assistance for this project.
- The leadership and technical staff of Wheat Marketing Center, Inc and the Northern Crop Institute for cooperating and contributing to this project.
- US Wheat Associates and the USDA Federal Grain Inspection Service for contributing content included in section 2 and photographs to enhance many sections of this project.
- Photographer Burt Peterson for his remarkable ability to capture the essence of a technical process in a single photo frame.
- The Wheat Foods Council for granting permission to use its photos and diagrams to enhance the material.

# ***Section 1: NAEGA Contract Terms***

---

*North American Export Grain Association, Inc. No. 2 ..... 2*

## North American Export Grain Association, Inc. No. 2

Most of the export grain shipped from the USA and/or Canada sold free on board (FOB) is contracted under the terms and conditions of the North American Export Grain Association, Inc. No. 2 contract, often referred to as simply, NAEGA No. 2.

Under this type of transaction, the seller is obliged to have grain available for delivery at the export loading facility to buyer's nominated vessel at the delivery time specified in the contract, and to effect delivery to the vessel at the end of the loading spout. This signifies that the risk of loss shall pass to buyer on delivery at discharge end of the loading spout. However, unless otherwise spelled out in the contract, seller retains title to the commodity until he has been paid in full (clause 25 of NAEGA No. 2).

Some of the terms and conditions spelled out in this contract are: the complete names and addresses of the buyer and seller, quantity, quality, dates of delivery, price, payment terms, and shipping documents seller is required to present to buyer for payment. In addition to these important terms, the contract will also include clauses that spell out the rights and obligations of both parties when situations make delivery impossible or outside of the agreed upon terms and condi-

tions. These clauses include provisions for failure to take delivery on time or take delivery, carrying charges to be paid for situations where seller is obliged to carry the commodity for buyer's account, strikes or other causes of delay in delivery, default by either party, and a clause that limits the liability of seller to the act of delivering the commodity at the discharge end of the loading spout and to presentation of the contractually required documentation (clause 26, Limitation of Liability).

Additionally, as most FOB contracts are sold with a loading rate guarantee, the NAEGA No. 2 contract may include Addendum No. 1 which will incorporate the terms and conditions governing settlement of laytime (time lost and/or gained, demurrage and/or despatch) at load.

Another important addendum is the arbitration clause. This clause specifies how buyer and seller agree to settle any controversy or claim that results from a dispute or breach of contract by either party. Arbitration under NAEGA No. 2 is settled in New York City subject to, and in accordance with International Arbitration rules of the American Arbitration Association.

# *Section 2: Overview of U.S. Wheat Inspection*

---

<i>Wheat Classing</i> .....	4
<i>Wheat Production, Distribution, and Exports</i> .....	5
<i>Federal Grain Inspection Service</i> .....	7
<i>Official Weighing Services</i> .....	10
<i>Official Inspection Services</i> .....	12
<i>Determining Wheat Quality</i> .....	14
<i>Grade Designations</i> .....	18
<i>Uniform Inspection Plan (Cu-Sum) And Optional Factors</i> .....	19
<i>Discrepancy Report Process</i> .....	20
<i>Official U.S. Standards For Wheat</i> .....	21
<i>Wheat Sample Breakdown Chart</i> .....	26

“Section 2: Overview of U.S. Wheat Inspection” of *Wheat and Flour Testing Methods: A Guide to Understanding Wheat and Flour Quality: Version 2* is taken, with permission, from *Overview of U.S. Wheat Inspection*, September 2007, U.S. Wheat Associates.

## Wheat Classing

There are eight classes of wheat: durum, hard red spring, hard red winter, soft red winter, hard white, soft white, unclassified, and mixed.

“Mixed wheat” is the class designation for shipments that contain less than 90 percent of one wheat class and more than ten percent of one or more other classes. “Unclassed wheat” is the class designation for any variety that cannot be classed under criteria of the official U.S. wheat standards.

## U.S. Wheat Quality

One of the major strengths of the U.S. grain production and marketing system is the variety of grades, classes, and prices that it can offer customers around the world. Dramatic differences in topography, soils, and climate from one region to another make this variety possible. By building on these natural advantages, seed breeders, researchers, farmers, grain handlers, and merchandisers are continually seeking to expand both the type and quality of wheat the United States can make available to its customers.

Class	Subclass	Vitreous Content
Hard Red Spring (HRS)	DNS - Dark Northern Spring	≥ 75 % DHV *
	NS - Northern Spring	25-74 % DHV
	RS - Red Spring	< 25 % DHV
		* Dark Hard and Vitreous
Hard Red Winter (HRW)	No Subclasses	None
Hard White (HW)	No Subclasses	None
Soft White (SW)	SW - Soft White	None
	WC - White Club	None
	WW - Western White	None
Soft Red Winter (SRW)	No Subclasses	None
Durum (DU)	HAD - Hard Amber Durum	≥ 75 % HVAC *
	AD - Amber Durum	60 – 74 % HVAC
	DU - Durum	< 60 % HVAC
		* Hard and Vitreous of Amber Color

# Wheat Production, Distribution, and Exports

## Geographic Production Areas

Wheat is grown in most of the 50 states of the United States. The kind and quantity of wheat grown varies widely from one region to another.

**Hard Red Winter** – Grown in the Great Plains and California, and shipped via the Gulf of Mexico and Pacific ports. Hard red winter wheat is an important, versatile bread wheat with excellent milling and baking characteristics. It has medium to high protein (10.0 to 13.0 percent), medium hard endosperm, red bran, medium gluten content, and mellow gluten. It is used in pan breads, Asian noodles, hard rolls, flat breads, and general purpose flour.

**Hard Red Spring** – Grown primarily in the North Central region of the United States and shipped via the Pacific, Gulf of Mexico, and Great Lakes ports. Hard red spring wheat is an important bread wheat with excellent milling and baking characteristics. It has high protein (12.0 to 15.0 percent), hard endosperm, red bran, strong gluten, and high water absorption. It is used in pan breads, hearth breads, rolls, croissants, bagels, hamburger buns, pizza crust, and for blending.

**Soft Red Winter** – Grown in the eastern third of the United States and shipped via Gulf of Mexico, Atlantic, and Great Lakes ports. Soft red winter wheat is a high-yielding wheat

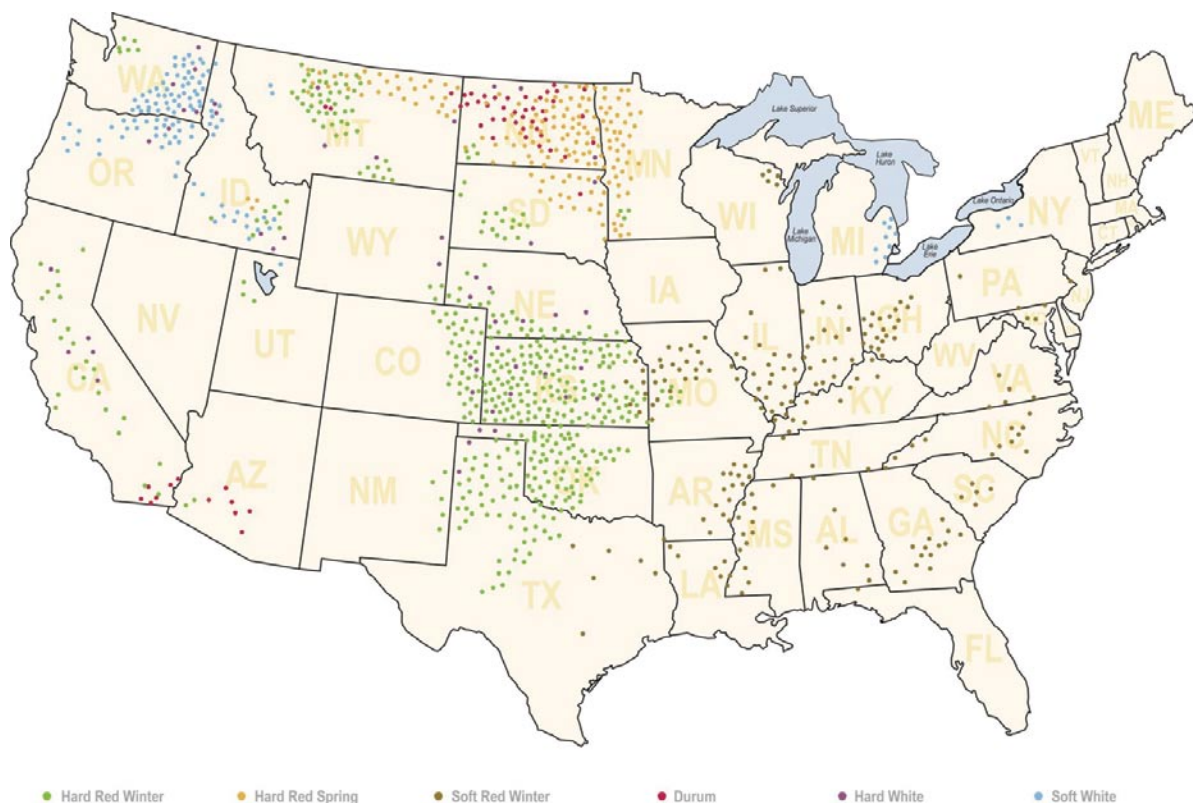
with low protein (8.5 - 10.5 percent), soft endosperm, red bran, and weak gluten. It is used in pastries, cakes, cookies, crackers, pretzels, flat breads, and for blending flours.

**Soft White** – Grown primarily in the Pacific Northwest region of the United States and shipped via Pacific ports. Soft white wheat has low protein (8.5 to 10.5 percent) and low moisture, and provides excellent milling results. It is used in flat breads, cakes, biscuits, pastries, crackers, Asian-style noodles, and snack foods.

**Durum** – Grown primarily in the North Central and desert Southwest regions of the United States and shipped via Gulf of Mexico, Great Lakes, and Pacific ports. Durum wheat is the hardest of all wheat classes with a high protein content (12.0 to 15.0 percent), yellow endosperm, and white bran. It is used in pasta, couscous, and some Mediterranean breads.

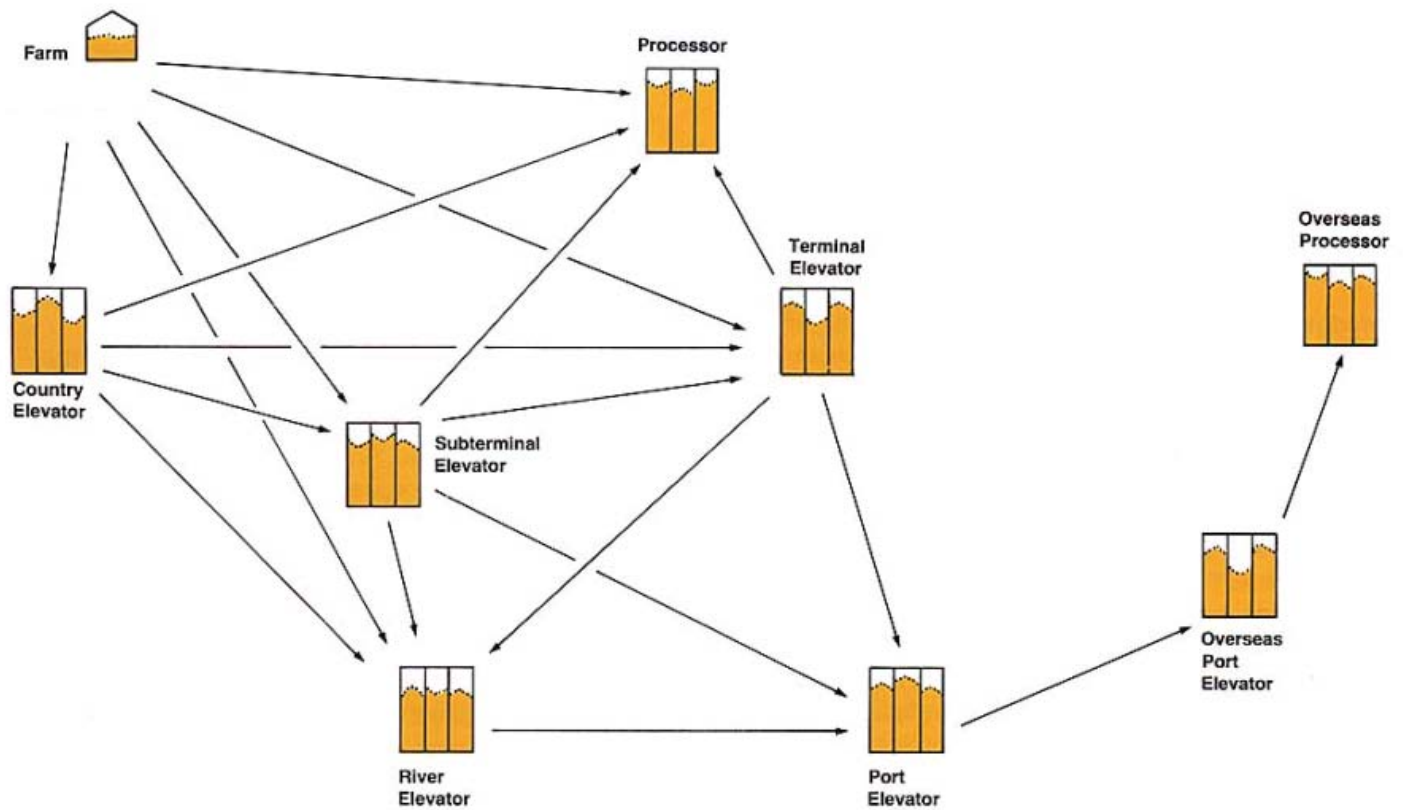
**Hard White** – The newest class of U.S. wheat, grown in California, Colorado, Idaho, Kansas, Montana, Nebraska, Oklahoma, and Washington, and when available for export, shipped via Pacific and Gulf of Mexico ports. Hard white wheat has a hard endosperm, white bran, and a medium to high protein content (10.0 to 14.0 percent). It is used in Asian noodles, whole wheat or high extraction flour applications, pan breads, and flat breads.

*Areas of U.S. Wheat Production, by Class*



Annually, the United States exports approximately half of its total wheat production. Of the exported volume, more than one-third is the class hard red winter and one-quarter is hard red spring. Soft red winter, soft white, durum and mixed wheat make up the remainder.

*The general flow of grain from the farm through the distribution system to the domestic and overseas processors.*





## Federal Grain Inspection Service

The Federal Grain Inspection Service, commonly referred to as FGIS, became an Agency of the U.S. Department of Agriculture (USDA) in 1976 under the United States Grain Standards Act. The Department of Agriculture Reorganization Act of 1994 merged FGIS with the Packers and Stockyards Administration to form a new agency, Grain Inspection, Packers and Stockyards Administration (GIPSA). The merge combined many administrative functions, but FGIS continues program delivery activities as a program within GIPSA.

FGIS administers a nationwide system for officially inspecting and weighing grain and other commodities. It provides services through field offices, sub-offices, and duty points in 17 states. FGIS field offices also oversee the performance of state and private agencies, which provide official services at other domestic grain markets on FGIS' behalf. Six state agencies are delegated to mandatory export weighing and inspection services.

The U.S. Grain Standards Act, with few exceptions, requires official inspection and weighing of export grain sold by grade. Official services are provided upon request for grain in domestic commerce. The Agricultural Marketing Act (AMA) of 1946 authorizes similar inspection and weighing services for rice, pulses, and many processed grain products. The exceptions in the mandatory inspection requirements include grain that is not sold or described by grade; for grain exporters shipping less than 15,000 metric tons of grain abroad annually; for grain exported by train or truck to Canada or Mexico; for grain sold as "seed"; and for grain transhipped through the United States in a bonded identity preserved fashion.

### National Inspection System

The structure and composition of the national inspection system is unique, comprised of federal, state, and private laboratories all under the direct oversight of FGIS. State and private laboratories provide impartial service to the domestic market. Federal and state export laboratories provide mandatory weighing (See page 10) and inspection services (See page 12) at all export grain facilities. There are five basic operations performed at export when officially going aboard a ship: stowage examination, weighing, sampling, inspection, and certification.

At both export and domestic inspection sites, there is a cadre of auditors and supervisors that monitor official personnel performance to ensure accuracy and impartiality.

The success of the national inspection system is due, in part, to the precise testing procedures, equipment criteria, and



*Quality Assurance Specialist*

employee conduct standards established and enforced by FGIS. The official system delivers accurate and consistent results, and protects against waste, fraud, and abuse.

### Ensuring Quality

Every FGIS field office has a quality assurance specialist who is trained to ensure that all inspectors in the area are performing accurately and according to instructions.

The FGIS Board of Appeals and Review is comprised of the Agency's most senior inspectors who make final determinations on grain quality assessments. They monitor and ensure the accuracy of all inspectors, including the quality assurance specialists.

FGIS re-engineered its quality assurance/quality control (QA/QC) program to capitalize on today's technology, using computers and automated systems to provide frontline inspectors with the information needed to get the job done right the first time and preclude quality analysis problems. The quality control system ensures that all inspectors align with the Board of Appeals and Review and that all equipment operates properly and is calibrated to the national reference methods.

### U.S. Grain Standards and Commodities Inspection

Official U.S. grain standards are used to describe the physical and biological properties of grain at the time of inspection. Grades, class, and condition reported on official certificates are determined based on factors defined in these standards.

Factors vary by grain and may include test weight per bushel; and percent — by weight, of damaged kernels, foreign materials, broken kernels, and other factors. Grades issued

under U.S. standards represent a sum of these factors. The certificate also notes certain conditions of the grain such as moisture content and infestation. Regardless of average new crop quality, no seasonal adjustments are made to the U.S. standards.

Standards exist for 12 grains (listed from largest to smallest volume inspected): corn, wheat, soybeans, sorghum, barley, oats, rye, flaxseed, sunflower seed, triticale, mixed grain, and canola.

Commodities such as rice, pulses, and hops have similar standards for grade and factors. Other commodities and a wide range of processed products, including flour, food mixes, edible oils, and other cereal food products, have no official USDA standards. FGIS, can however, perform the physical, chemical, and microbiological tests — using official laboratory methods of the Association of Official Analytical Chemists — requested in contract specifications.

Official inspection of export grain is mandatory, with the exceptions listed above. Official personnel employed or licensed by FGIS obtain representative samples using approved equipment. The grain is inspected and the grade is reported on a white certificate, which represents the entire lot inspected.

Standards used to inspect grain and commodities are updated regularly through public rulemaking procedures and represent currently accepted market practice.

## **FGIS Rulemaking Procedures**

Official U.S. Standards for Grain are based on public comment; they are not unilaterally prescribed by the U.S. government. Before FGIS can establish or revise any of its standards or regulations, the agency must publish a proposal in the *Federal Register*, the U.S. government's legal newspaper.

Most *Federal Register* proposals have a 60-day comment period during which FGIS solicits the views of all sectors of the grain industry — breeders, producers, handlers, exporters, and importers. FGIS transmits the proposals to the agricultural offices of U.S. embassies worldwide and issues a press release. Current press releases may be found on FGIS' web site, [www.gipsa.usda.gov/GIPSA/newsReleases?area=newsroom&subject=landing&topic=nr](http://www.gipsa.usda.gov/GIPSA/newsReleases?area=newsroom&subject=landing&topic=nr). FGIS also mails specific proposals to any person upon request.

Each proposal contains instructions for submitting comments including a mailing address, fax number, and e-mail address.

After the comment period closes, FGIS decides on the appropriate action based on the views expressed. FGIS publishes its decision as a “final rule” in the *Federal Register*. Changes to the standards generally take effect 1 year after the final rule is published and at the beginning of the marketing year (June 1 for wheat).

FGIS does not change the standards each year to reflect the fair average quality of the crop; rather, the standards remain fixed until specifically revised. Revisions to the standards are typically initiated by FGIS in response to expressed market needs. FGIS' challenge, therefore, is to provide the market with standards that are a benchmark for the description of grain quality and, at the same time, continue to provide market-relevant information.

## **Research Projects**

FGIS is committed to developing new technology or expanding the use of current technology to measure relevant wheat quality attributes. The market needs accurate test methods to differentiate the intrinsic functional qualities of wheat that impact the end products made from it. Official analysis must be timely, reliable, and cost-effective; and the results must be understandable throughout the market. FGIS is studying current methods used in evaluating the functional properties of wheat, such as the Farinograph, in an effort to improve the overall accuracy of these tests. FGIS is also working cooperatively with the USDA Agricultural Research Service, universities, and other entities to develop new, more practical tests for evaluating the functional properties of U.S. wheats.

The grain industry needs fast, reliable tests to detect the presence of mycotoxin-contaminated grain. In addition to approving deoxynivalenol and zearalenone test kits, FGIS will be developing and implementing official testing services for ochratoxin A, T-2, and HT-2.

In 2005, FGIS implemented a global all-class wheat protein calibration that replaced the six individual wheat class protein calibrations previously used in official inspection. Artificial neural network (ANN) calibration techniques were used to support development of the all-class wheat protein calibration and to improve the accuracy of protein predictions for the near-infrared transmittance (NIRT) instruments used in official inspection. Use of the single, more accurate, ANN wheat protein calibration makes it much easier for the commercial sector to align its instruments with the official system. In 2006, GIPSA developed and implemented a protein-based NIRT calibration to determine wet gluten content for hard red winter and hard red spring wheat.

All of these efforts are being taken to improve the level of service available through the national inspection system. Today's technology offers many possibilities for improving the system and providing more meaningful information to the customer. FGIS recognizes and accepts the challenge of harnessing technology to improve the national inspection system.

### **International and Domestic Program Development**

The FGIS Office of International Affairs (OIA) is the Agency's liaison to importers and other governments and international traders. OIA explains the national inspection system, U.S. grain standards, and commodity inspection programs; conducts briefings and educational visits; assesses foreign inspection and weighing techniques; and responds to inquiries about quality and weight of U.S. grain shipments. FGIS also coordinates cooperative studies to monitor the quality and weight of grain shipments between U.S. and destination ports.

For further information, contact:

USDA, GIPSA, Federal Grain Inspection Service  
Office of International Affairs  
Stop 3620  
14th and Independence Ave., S.W.  
Washington, D.C. 20250-3620  
Telephone: (202) 720-0226  
FAX: (202) 720-1015

Or visit the GIPSA Web site:

*[www.gipsa.usda.gov/GIPSA/webapp?area=home&subject=grpi&topic=is](http://www.gipsa.usda.gov/GIPSA/webapp?area=home&subject=grpi&topic=is)*

## Official Weighing Services

Official weighing is mandatory for all grain exported from the United States by sea. The weight may be certified separately or included on the official inspection certificate. Official supervision of 100 percent of the weighing process is required on export grain.

During weighing operations, trained technicians employed or licensed by FGIS observe and verify weighing and loading of grain, and monitor scales and grain flow security. Official personnel must know a variety of weighing systems, their proper use, and signs of system breakdowns. This knowledge is essential to the certification of weights.

Scales used for official weighing of grain and commodities must be installed and operated under FGIS guidelines. Scales at export elevators are tested every 6 months and must remain accurate to 0.01 percent. Accuracy of standard weights used to calibrate scales is verified every 3 years or as needed.

In addition to scale testing, FGIS calibrates 13 railroad master track scales to the National Institute of Standards and Technology official track scale under an agreement with the American Association of Railroads. These master scales are used to calibrate track scales across the United States.

### Official Weighing Procedures

#### Electronic Weighing Systems

Electronic weighing systems consist of a load receiving element (e.g., a weigh hopper or platform, with load cells), an indicating element (e.g., digital instrument), a printer, and the associated material handling equipment. The load cell senses the amount of applied load — the weight — in the load receiving element and produces an output voltage that is sent to the digital instrument that converts the output voltage into a digital display — a readout of the weight.

The tape printer records the weight displayed onto a tape or ticket for a permanent record. There are two types of electronic scales: levertronic and full electronic.

#### Levertronic Scales

Levertronic scales are mechanical scales that have been converted to electronic scales by inserting a load cell in the lever system. The weighbeam or dial used to obtain and print a weight is replaced with a digital instrument and printer.

#### Full Electronic Scales

In full electronic scales, the load-receiving element is either supported by, or rests on, the load cells.

The control room in an export elevator is the weighing operations control center. It may be in the elevator or a separate building. Digital instruments, printers, and control boards are located in the control room. A digital instrument may have some form of process control that allows the operator to manually or automatically operate the gates of the garner and scale.

In the manual mode, the operator controls the operation of each scale cycle; in the automatic mode, the scale cycle repeats in succession. Control boards are scaled-down diagrams of the elevator's grain handling systems. Elevator personnel can control bin selection, tripper movement, diversion points, legs, conveyor belts, and slides and gates from this board. Official weighing personnel monitor export grain flow after weighing and sampling to assure all the grain weighed and sampled is, in fact, delivered to the vessel.

#### Scale Tapes

During the operation of an electronic weighing system, the official weigher constantly verifies that the weight value displayed on the digital instrument is the same as the printed value on the scale tape or ticket to assure proper system operation and to detect any printer malfunction.

The weight of each draft is added to determine the subplot total. The official weigher records the number of the subplot on the tape and initials the total weight. When the tape is removed from the printer, the weigher initials it and records the time, carrier identification, kind of grain, tape number, and scale numbers. If this information is printed on the tape automatically, the weigher verifies the accuracy of the information and initials it.

#### Certified Capacity

The certified capacity of a scale is the maximum weight limit that has been approved by FGIS for a specific scale. The certified capacity and the minimum division size are prominently displayed on the front of the digital instrument. If the weight of a draft of grain is greater than the certified capacity of the scale (overdraft), the weight in excess of the certified weight capacity is not certified.

#### Grain Flow Security

When grain is shipped out of an elevator, the responsibilities of official personnel do not end with the weighing of the grain, but extend to the carrier that is to be loaded. An official weight certificate certifies that there is an exact weight of grain in an identifiable carrier, and it must be accurate. Every weighing position in the elevator, and every seal and lock ensures the accuracy of the certificate.

### **Automated Scale Systems**

Grain elevators actually own and operate the scales, but at least one FGIS employee must be present during official weighing to physically supervise the operation of scales and grain flow throughout the elevator.

Export grain elevators continually strive to reduce costs by operating their facilities more efficiently. To achieve this, they use computerized material handling, weighing, and inventory control systems. To keep pace with this progress, FGIS has developed an automated system to monitor and supervise the weighing process officially.

Using the automated method, a computer compares the displayed weight against the printed weight data using parity checking. Parity checking is an electronic method that compares the weight data transmitted from the bulk weigher to the weight data received by the printer before printing. Any discrepancies generate an alarm signal.

The computerized control system also can be programmed to set up automatically certain grain routing paths appropriate for any particular application. It also can be programmed to print a record of all grain routing paths: scale and bin selection, system component identification, date, time, etc. The system is under FGIS control and is not accessible to elevator personnel.

### **The Official Weight Certificate**

Weighing documentation provides a backup for official weight certificates. The logs, tapes, and tickets are admissible as prima facie court evidence and can be used as proof that certificates are correct. Therefore, the weigher must enter clear, concise, and accurate information. Unusual events that might relate to the weight (e.g., light loads, open hatch covers, and appearance of pilferage) are documented on the appropriate scale tape or ticket. FGIS shift supervisors review this information to assure that the official weight certificate represents the true weight of the cargo.

The weight is recorded in pounds on the Official Grain Weight Certificate. Metric weight conversion is available upon request in the sales contract.

## Official Inspection Services

To be officially graded, grain must be inspected according to provisions of the United States Grain Standards Act. This means the equipment and procedures used are approved and checked regularly for accuracy, and inspectors are tested for proficiency in carrying out their inspection duties. The U.S. Congress gave FGIS the responsibility for administering and supervising a uniform, nationwide system of official inspection. Voluntary inspections not performed by FGIS or official agencies delegated by FGIS are not controlled or supervised by the U.S. government.

There are five basic operations performed when officially inspecting and weighing grain going aboard a ship: stowage examination, weighing, sampling, inspection, and certification.

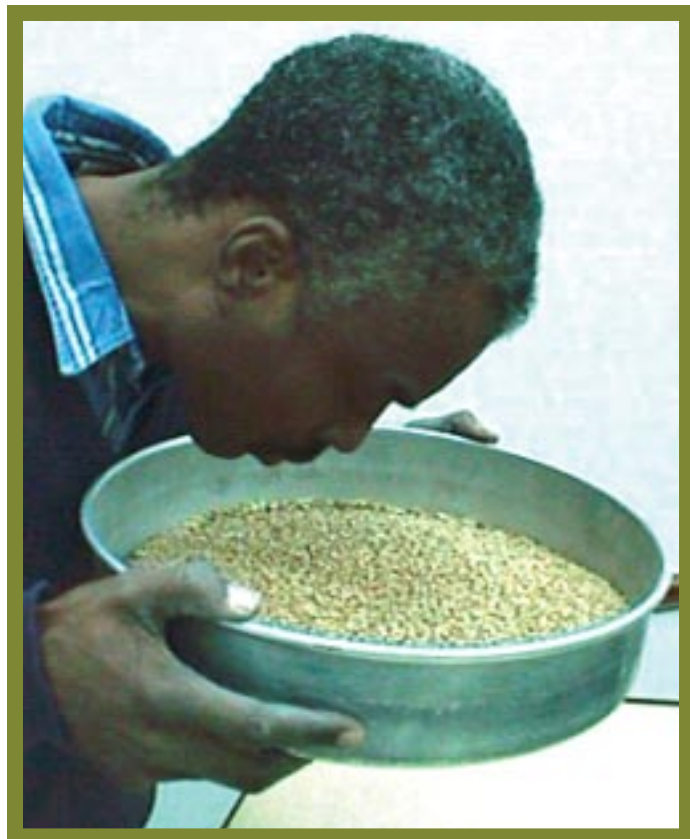
Shipholds are examined for potential defects such as rust scale, insect infestation, oil sludge, and water. Before loading can begin, the vessel must be substantially clean, dry, and ready to receive grain. The results of the stowage examination are reported on the Official Stowage Examination Certificate.

### Stowage Examination

When the vessel arrives in port, the inspection process usually begins with a stowage examination while the ship is still at anchor in the harbor. To perform the stowage examination, official inspection personnel go aboard the ship and enter the shipholds.

### Sampling

During grain handling, there is a continual segregation of particles based on particle size, density, and texture differences. During loading, the larger-sized materials tend to



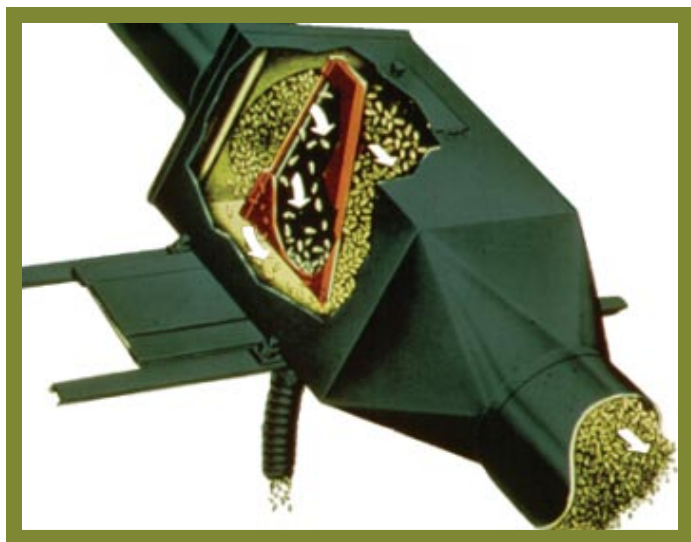
*Checking for Unusual Odors*

migrate away from the spout line flow and form strata or layers. The inner core under the loading spout is composed primarily of the smaller-sized material. When the grain is unloaded, a reverse segregation occurs; the inner core leaves the silo or shiphold first.

The diverter-type (D/T) mechanical sampler draws the most representative sample of any grain lot. Although D/T samplers vary in design, all operate on the same principle. Installed at the end of a conveyor belt or in a spout, they draw the sample by periodically moving a pelican-like device through the entire grain stream. The frequency of these “cuts” is regulated by timer controls. After the grain enters the primary sampler, it flows through a tube into a secondary sampler (SM) to reduce the size of the sample. From the secondary sampler the sample flows to a collection box or sample bucket located inside the FGIS onsite laboratory, under the control of official personnel.

### Inspection Procedures

During sampling, the inspector periodically examines the samples collected in the laboratory collection boxes for objectionable odors. The inspector draws off a portion of



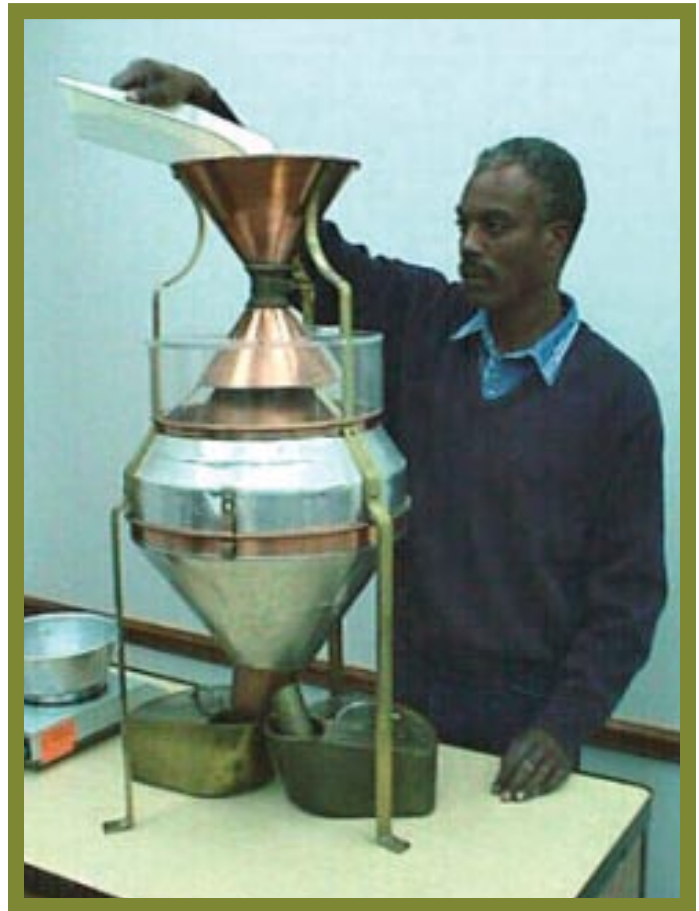
*Cutaway Diagram of a D/T Sampler*



*Looking for Live Infestation*

the wheat from the collection box into a sieve pan and places his nose into the wheat and smells the grain for unusual or unnatural odors. Then, the inspector examines the sample to see if any insects are present. The inspector sieves the entire sample and performs a visual examination for live insects that fall through the sieve and into the bottom pan. For more information on infested lots, see page 23.

After passing the preliminary tests, the sample is divided into two portions of approximately 1,350 grams each: the work sample and the file sample. The work sample is used to determine the moisture and all grading factors. The file sample is maintained in a moisture-proof container at the laboratory and is stored in a locked compartment for 90 days after the inspection is completed. In the event there is any question regarding the quality of the grain, the file sample is available for review.



*Boerner Divider*

A Boerner Divider is used in the inspection laboratory to break down the representative sample into smaller sized portions for factor determinations. Each time grain passes through the divider, it divides the sample into two approximately equal portions. A pictorial flow chart of sample break down procedures is shown on page 26.

## Determining Wheat Quality

FGIS determines the quality of wheat through standardized testing methods in accordance with the *Official U.S. Standards for Wheat* (Appendix 1 on page 26) and *FGIS Grain Inspection Handbook II*, Chapter 13, which can be found on the GIPSA Web site at <http://archive.gipsa.usda.gov/reference-library/handbooks/grain-insp/grbook2/wheat.pdf>.

FGIS is required to test for a number of factors. Some of the required factors affect the numerical grades U.S. No. 1 through U.S. No. 5 and U.S. Sample Grade, and some do not. The grade-determining factors are: test weight, heat damage, total damaged kernels, foreign material, shrunken and broken kernels, total defects, wheat of other classes, contrasting classes, and sample grade criteria. The other required factors which are non-grade-determining are wheat class, dockage, and moisture.

Official testing service is offered for other “optional” tests such as protein, falling number, single kernel hardness, and mycotoxin and pesticide residue analysis. FGIS provides these testing services upon request in the sales contract. Such optional tests are also available from private unofficial inspection companies.

### Grade-Determining Factors

#### Test Weight per Bushel

Test weight per bushel is the weight of the grain required to fill a level Winchester bushel measure 2,150.42 cubic-inch (35.24-liter) capacity. The factor “test weight per bushel” is determined using an approved apparatus, which has a kettle capacity of one dry quart (1.101 liter). This determination is made on the basis of 1,350 grams of wheat cut from the representative sample using a Boerner Divider.

To determine test weight, the work sample is poured into the closed hopper centered over the kettle. The valve is quickly opened to allow the grain to fill the kettle. A standard stroker held in both hands with the flat sides in a vertical position is used to remove the excess grain from the top of the kettle with three full-length, zigzag motions. The kettle is carefully placed on the scale platform. The weight is read by an electronic scale that converts the gram weight to either pounds per bushel or kilograms per hectoliter.

Test weight per bushel is a grading factor. Generally, it is expressed in pounds per Winchester bushel, but upon request it will be converted and reported in kilograms per hectoliter.

#### Shrunken and Broken Kernels

Shrunken and broken kernels is a grading factor for wheat. To determine shrunken and broken kernels in wheat, the inspector places 250 grams on a  $0.064 \times \frac{3}{8}$  inch (1.626 mm  $\times$  9.545 mm) oblong-hole sieve and mechanically shakes the sieve 30 times from side to side. The machine used to sieve the sample, a Strand Sizer, has a stroke counter and always starts and stops in the same position. One complete stroke takes approximately 1 second.

#### Damaged Kernels

Damaged kernels is a grade-determining factor and is composed of two categories: heat damage and total damage. Heat-damaged kernels are reported separately from all other types of kernel damage but are included in the total damage.

The inspector visually examines a portion of the wheat sample — 50 grams for heat damage and 15 grams for other damage types — to determine whether any kernels have been materially discolored or damaged by physical or biological factors.



*Procedures for Determining Test Weight*



## Foreign Material

Foreign material is a grade-determining factor. It is determined on a 50-gram portion after the removal of dockage and shrunken and broken kernels. The inspector manually removes all material other than wheat.

The inspector must be well trained and capable of distinguishing different types of damage. Those conditions that may be mistaken for damage (such as dirt stains which appear to be mold) must be recognized also.

## Visual Grading Aids

FGIS maintains a visual grading aids system which serves as the foundation for the national inspection system's subjective quality control program, providing an effective management tool for aligning inspectors and assisting them in making proper and consistent subjective grading decisions. The system consists of a series of commodity specific visual reference images (VRI), which includes descriptive text, and interpretive line prints (ILP). With regular use, these visual references help to control and diminish the impact of ordinary perceptual differences.

VRI focus on individual kernel inspection criteria, whereas the ILP serve as a visual reference in the assessment of the commodity's general appearance or overall color. A special sample box is used to compare the grain being graded with the ILP. To compare the sample with the ILP, place the 5- x 7-inch photographic print in one side of the box and the grain in the opposite side. This allows for the comparison of the grain and the ILP under similar conditions. On the reverse side of each print is an explanation of the condition illustrated on the photograph and procedures for use of the photograph and box. The only ILP for wheat is for the color of hard white wheat, applied only upon request.

VRI and ILP are available for viewing at all official inspection service provider facilities; they can also be viewed on-line by visiting GIPSA's Web site at [www.gipsa.usda.gov](http://www.gipsa.usda.gov). When viewing images on-line, it is important to remember that the hardware (monitor, graphics card, etc.) used to display images influences the appearance or color accuracy of those images. As a result, the images may have a slightly different appearance when viewed on different makes/models of computer and display.

Visual reference images and interpretive line prints are available for purchase from Seedboro Equipment Company in Chicago, Illinois ([www.seedburo.com](http://www.seedburo.com)). The following is a list of the available visual reference images for wheat damage:

- W-1.0 Black tip damage (Fungus)
- W-2.0 Scab damage
- W-3.0 Frost damage (Blistered)
- W-3.1 Frost damage (Candied)
- W-3.2 Frost damage (Discolored black or brown)
- W-3.3 Frost damage (Flaked)
- W-4.0 Germ damage
- W-4.1 Mold damage
- W-4.2 Germ damage (Bleach method)
- W-5.0 Green damage (Immature)
- W-6.0 Heat damage (Durum)
- W-6.1 Heat damage (Other than durum)
- W-7.0 Other damage (Mold)
- W-8.0 Sprout damage
- W-8.1 (A) Insect chewed, (B) Sprout sockets
- W-9.0 Weevil or insect bored
- W-9.1 Insect chewed wheat (Not damaged)
- (W) OF-17.0 Unknown foreign substance (Pink wheat)
- (W) OF-23.0 Smut in wheat (Tagged ends)
- (W) OF-30.0 Threshed and unthreshed kernels

## Total Defects

Total defects, a grade-determining factor that is determined as a further measure of quality, is the sum of shrunken and broken kernels, foreign material, and damaged kernels.

## Contrasting Classes

Contrasting classes is a grade-determining factor that is assessed on a 15-gram portion after the removal of dockage and shrunken and broken kernels.

Contrasting classes are:

1. durum wheat, soft white wheat, and unclassified wheat in classes of hard red spring wheat and hard red winter wheat.
2. hard red spring wheat, hard red winter wheat, hard white wheat, soft white wheat, soft red winter wheat, and unclassified wheat in the class durum wheat.
3. durum wheat and unclassified wheat in the class soft red winter wheat.
4. durum wheat, hard red spring wheat, hard red winter wheat, soft red winter wheat, and unclassified wheat in the classes hard white wheat and soft white wheat.

## Wheat of Other Classes

Wheat of other classes is a grade-determining factor that is assessed on a 15-gram portion after the removal of dockage and shrunken and broken kernels. The inspector picks out classes of wheat that are not the predominating class.

## Mandatory Non-Grade-Determining Factors

Moisture and dockage are two quality factors that must be determined, but do not affect the numerical grade.

### Moisture

The Grain Analysis Computer Model 2100 (GAC 2100), manufactured by Dickey-John Corporation, Auburn, Illinois, is the official moisture meter for the national inspection and weighing system. The GAC 2100 is calibrated to the USDA air-oven method (1 hour at 130 degrees Celsius).

### Dockage

Dockage is determined with a special machine called the Carter Dockage Tester. Dockage, like moisture, does not influence the numerical grade. It is an additional test made by the inspector and reported separately on the certificate.

The Carter Dockage Tester, using aspiration (air) and a combination of riddles and sieves, prepares a sample for grading by removing the readily separable material.



*Carter Dockage Tester*

Generally, this material consists of all matter that is lighter than, larger than, and smaller than wheat.

The material removed by a dockage tester is readily separated and does not require the additional sophisticated equipment found in the cleaning houses of mills.

## Optional Non-Grade-Determining Tests

Customers may require additional quality tests. These optional tests can be performed by private unofficial inspection laboratories or officially by FGIS. Check with the supplier, FGIS, or U.S. Wheat Associates on the availability of any of these optional testing services. FGIS can officially test for protein, falling number, single kernel hardness, aflatoxin, vomitoxin, fumonisin, and certain pesticide residues. Unofficial laboratories can perform additional optional tests, such as, wet gluten, sedimentation, alveograph, farinograph, extensigraph, mixograph, and 1,000-kernel weight. Any optional testing must be requested in the sales contract.

### Protein

FGIS uses near-infrared transmittance (NIRT) spectroscopy to determine protein for official inspections.

FGIS adopted the combustion nitrogen analyzer in 1994 as the standard reference method for determining wheat protein because it provides accurate and consistent results, uses no hazardous chemicals, and has a short analysis time. FGIS' wheat protein laboratory is certified ISO 9002 compliant by the International Standards Organization.

All field NIRTs are calibrated to the standard protein reference method, the Combustion Nitrogen Analyzer, to ensure the accuracy of the results. Each NIRT instrument is checked for accuracy daily using a set of six standard reference samples. If the daily average of the results on the standard reference samples differs by more  $\pm 0.10$  percent, the instrument is adjusted and rechecked before use. The goal is to have a daily tolerance within  $\pm 0.05$  percent difference. The same set of standard reference samples is used throughout the FGIS national system for checking official NIR instruments.

The Combustion Nitrogen Analyzer consists of a computer-controlled, closed-system, combustion process, and a thermal conductivity detector.

Protein is usually reported on the 12.0 percent moisture basis. Upon request in the sales contract, FGIS will report protein on an alternate moisture basis, in addition to the 12.0 percent moisture basis.

Protein can be specified by the buyer in the following ways:

1. Ordinary protein: any protein level can be loaded,
2. Average protein: a weighted or mathematical average of the sublots with no limit on subplot variability,
3. Minimum or maximum protein with a weighted or math average of sublots where Cu-Sum (see Page 19) applies with limits on subplot variability, or
4. Modified minimum or maximum protein — sublots are weighted or mathematically averaged with a reduced Cu-Sum breakpoint. For example, a request for Northern Spring wheat, minimum 14.0 percent protein, with no subplot below 13.8 percent; or Soft White wheat, maximum 9.0 percent protein, with no subplot above 9.2 percent.

The grade and protein are issued on the same certificate. For example, if a maximum 10.0 percent protein is specified, the lot average cannot exceed 10.0 percent, no subplot can be higher than 10.5 percent, and all sublots must be within 1.0 percent of each other.

### **Falling Number (Hagberg)**

Falling number analysis is an indicator of kernel germination (sprouting) and the resulting increases in alpha amylase activity. Falling number results of 300 seconds or higher usually indicate that minimal amylase activity due to sprout damage is present. FGIS performs falling number tests as an optional service under the Agricultural Marketing Act (AMA) and reports results on the Commodity Inspection Certificate. Upon request, FGIS determines the FN in wheat meal at the FGIS Technical Services Division Laboratory in Kansas City, Missouri, and certain FGIS field offices and state agencies.

Falling number results are reported on a 14 percent moisture basis unless the buyer specifies another moisture basis.

Cu-Sum averaging is not available for falling number tests because falling numbers are not additive. Buyers can specify falling number tests in the following ways:

1. Cargo lot analysis where a single analysis is performed for the entire cargo,
2. “Liquefaction average” of sublots, or
3. Sublot minimum analysis where a limit is placed on each subplot.



*Falling Number Instrument*

### **Single Kernel Characterization**

Studies have been conducted under experimental milling conditions which show that single kernel characterization information can be used with other data such as test weight to provide an accurate prediction of the milling performance of a wheat sample. Such information may be useful to identify wheat for purchase that will perform better under processing conditions.

Specifically, the Single Kernel Characterization System (SKCS) analyzes exactly 300 wheat kernels from a 15 to 20-gram portion that is free from dockage, shrunken and broken kernels, and foreign material. Individual kernel size, weight, moisture, and crushing profile (hardness) are measured and displayed on a histogram. It also reports the range, average, and standard deviation for each of the four factors.

FGIS performs hardness testing as an optional service under the AMA and is reported on the Commodity Inspection Certificate.

## Grade Designations

The end product of all the analyzing, grading, and monitoring is the Official Export Grain Inspection Certificate. There are two options under which shiplot grain can be loaded and certified — “Option 1” and “Option 2.”

Under Option 1, the exact grade must be loaded.

Example: U.S. No. 1 (only No. 1 grade shipped)

Example: U.S. No. 2 (only No. 2 grade shipped)

Under Option 2, the exact grade specified or a better grade can be loaded. Option 2 gives the shipper more flexibility and gives the buyer a potentially better quality of grain.

Example: U.S. No. 2 or better (No. 1 and/or No. 2 shipped)

Example: U.S. No. 3 or better (No. 1, No. 2, and/or No. 3 shipped)

The buyer has the option to contract for quality superior or inferior to the U.S. grade. For example, the buyer may desire a test weight that is higher than the contract U.S. No. 2 minimum of 58 pounds per bushel (76.4 kilograms per hectoliter). Then the buyer would specify: U.S. No. 2 or better, except that minimum test weight is 60 pounds per bushel (78.9 kilograms per hectoliter).

### Special Grades

Special grades draw attention to unusual conditions in wheat and are made part of the grade designation. Definitions and examples of the designations for special grades in wheat are:

1. **Ergoty Wheat.** Wheat that contains more than 0.05 percent of ergot.  
Example: U.S. No. 2 or better Northern Spring wheat, Ergoty, Dockage 0.5 percent
2. **Garlicky Wheat.** Wheat in a 1,000-gram portion that contains more than two green garlic bulblets or an equivalent quantity of dry or partly dry bulblets.  
Example: U.S. No. 2 or better Soft Red Winter wheat, Garlicky, Dockage 0.6 percent
3. **Infested Wheat.** FGIS examines wheat for the presence of live weevils or other live insects injurious to stored wheat. The presence of eggs or larvae not visible to the naked eye cannot be detected and reported.

The presence of live insects does not affect the numerical grade of wheat; the special grade “infested” is added to the grade on the official certificate. The determination for the special grade “infested” is based on the lot as a whole or the official sample before removing dockage.

A sample is considered “infested” if it contains

1. two or more live weevils, or
2. one live weevil and 1 other live insect injurious to stored grain, or
3. two or more live insects injurious to stored grain other than live weevils.

Example: U.S. No. 2 or better Hard Red Winter wheat, Infested, Dockage 0.3 percent.

4. **Light Smutty Wheat.** Wheat in a 250-gram portion that has an unmistakable odor of smut or which contains smut balls, portions of smut balls, or spores of smut in excess of a quantity equal to 5 smut balls, but not in excess of a quantity equal to 30 smut balls of average size.

Example: U.S. No. 3 or better Hard Red Winter wheat, Light Smutty, Dockage 0.5 percent

5. **Smutty Wheat.** Wheat in a 250-gram portion that contains smut balls, portions of smut balls, or spores of smut in excess of a quantity equal to 30 smut balls of average size.

Example: U.S. No 2 or better Northern Spring wheat, Smutty, Dockage 0.4 percent

6. **Treated Wheat.** Wheat that has been scoured, limed, washed, sulfured, or treated in such a manner that the true quality is not reflected by either the numerical grades or the U.S. Sample grade designation alone.

Example: U.S. No. 1 Amber Durum wheat, Treated (limed), Dockage 0.2 percent

## Uniform Inspection Plan (Cu-Sum) And Optional Factors

During loading of an export grain vessel, FGIS follows a uniform loading plan for sampling and inspection. A shipment or “lot” of grain is divided into “sublots” to assess uniformity of quality. Sublot size is based on the hourly loading rate of the elevator and the capacity of the vessel being loaded. A sublot may represent from 250 to 1,600 metric tons. The grade and factors determined on each sublot must meet, within specified tolerances, the official grade and factors requested in the contract. The loading elevator supplies FGIS with a load order, which describes the quality requirements of the purchase contract. Sublots that do not meet tolerances are removed from the shipment or certified separately. Otherwise, FGIS certificates represent the entire lot of grain based on the average of sublot results at the time of loading.

The uniform inspection plan for shiplots is called the Cu-Sum Plan. It establishes statistically based tolerances, known as breakpoints, for accepting those occasional portions of a lot that, because of known sampling and grading variations, grade below the desired lot quality. The Cu-Sum Plan was adopted to ensure that the entire lot is within uniform quality tolerances.

The inspector uses an inspection log to record his findings for each sublot. Each log contains all of the factor results for each sublot, plus any other observations made by the sampler and inspector. It is a complete record of all inspection information concerning the lot. FGIS has developed an automated Cu-Sum plan that prints out a computer-generated inspection log.

For minimum and maximum protein, there are three criteria under Cu-Sum:

1. The average of all sublots must be no lower than the minimum percentage (or no greater than the maximum percentage) specified;
2. No sublot can be more than 0.5 percent lower than the minimum percentage (or more than 0.5 percent higher than the maximum percentage) specified; and
3. A statement indicating the actual protein range of the lot is shown on the certificate if the difference between the lowest and the highest protein determinations exceeds 1.0 percent and the contract does not specify a specific range limit.

For example, if a minimum 14.0 percent protein is specified, the lot must average at least 14.0 percent, no sublot result can be lower than 13.5 percent, and all sublots must be within 1.0 percent of each other.

The certified grade of the lot is based on a mathematical or weighted average of the sublot results. The results are reported on the official grain inspection certificate.

The inspection log is retained by FGIS, and a buyer can obtain a copy by requesting it in the contract.

## Discrepancy Report Process

The USDA has established a formal quality discrepancy process administered by the Foreign Agricultural Service (FAS) and investigated by FGIS. When an importer notes a discrepancy in quality or quantity compared to the original certificate, the importer can report the discrepancy to the FGIS Office of International Affairs (OIA) through the agricultural representative in the local U.S. Embassy.

The complainant should provide the U.S. representative with as much detailed information about the discrepancy as possible, such as the name of the vessel, the quantity of wheat involved in the discrepancy, where and when the vessel loaded in the United States, the quality factors involved, destination results, and how the samples were taken and testing methods used at destination.

FGIS will reanalyze the file samples (if the complaint is received within the 90-day file sample retention period). In cases where file samples are not available, all available documentation is reviewed for mistakes or errors made during the original inspection.

If the buyer chooses to submit a destination sample(s), FGIS analyzes it and compares the results to the original and review results. All loading documentation including the inspection log, certificates, and weighing records are reviewed. All information is evaluated, and a report of findings is prepared within 90 days of receipt of the discrepancy and sent to all interested parties through the agricultural counselor. FGIS does not issue new certificates nor do they act as arbitrators. They merely report the facts and suggest means of minimizing such differences in the future.

### Reasons for Quality Discrepancies

Most quality discrepancies reported by importers can be attributed to one or more of these factors.

1. Differences in factor results between FGIS and destination are often due to differences in samples tested. Destination testing performed on a non-representative sample will often yield factor results significantly different from those reported by FGIS (see page 14 for description of diverter-type samplers).
2. Differences in testing methods and procedures are contributing factors to differences in factor results.

Here are some examples of how these differences can affect results:

Example: Differences in dockage results are often due to a difference between samples due to obtaining non-representative samples and to using a method other than the Cater-Day Dockage Tester used by FGIS.

Example: Differences in shrunken and broken kernels can often be attributed to the use of a sieve size other than the 0.064-inch  $\times$   $\frac{3}{8}$ -inch oblong sieve (1.626-mm  $\times$  9.545-mm) used by FGIS. Some importers handpick the shrunken and broken kernels and do not use a sieve. This can contribute to significant differences in SHBN results between FGIS and destination.

Example: Differences in subjective factors such as damaged kernels may be due to differences in inspectors' interpretations. That is why FGIS uses interpretive line slides (ILS) as a guide for inspectors' determinations of damaged kernels (see page 18 for information on ILS slides).

The Office of International Affairs works with USDA cooperators like USW to show inspectors our testing and grading procedures. A decline in the number of complaints over the past several years can be partly attributed to FGIS' wheat grading seminars and in-country training of local inspectors.

# Official U.S. Standards For Wheat

## General Provisions

**NOTE** — Compliance with the provisions of these standards does not excuse failure to comply with the provisions of the Federal Food, Drug, and Cosmetic Act, or other federal laws.

## General Terms Defined

### Grains for which standards are established

Grain refers to barley, canola, corn, flaxseed, mixed grain, oats, rye, sorghum, soybeans, sunflower seed, triticale, and wheat. Standards for these food grains, feed grains and oilseeds are established under the United States Grain Standards Act.

### Definition of other terms

Unless otherwise stated, the definitions in this section apply to all grains. All other definitions unique to a particular grain are contained in the appropriate subpart for that grain.

- a. *Distinctly low quality.* Grain that is obviously of inferior quality because it is in an unusual state or condition and that cannot be graded properly by use of other grading factors provided in the standards. Distinctly low quality includes the presence of any objects too large to enter the sampling device; i.e., large stones, wreckage, or similar objects.
- b. *Moisture.* Water content in grain as determined by an approved device according to procedures prescribed in FGIS instructions.
- c. *Stones.* Concreted earthy or mineral matter and other substances of similar hardness that do not disintegrate in water.
- d. *Test weight per bushel.* The weight per Winchester bushel (2,150.42 cubic inches) as determined using an approved device according to procedures prescribed in FGIS instructions. Test weight per bushel in the standards for wheat is determined after mechanically cleaning the original sample and is recorded in whole and tenth pounds to the nearest tenth pound.
- e. *Whole kernels.* Grain with one quarter or less of the kernel removed.

## Principles Governing the Application of Standards

### Basis of determination

- a. *Distinctly low quality.* The determination of distinctly low quality is made on the basis of the lot as a whole at the time of sampling when a condition exists that may or

may not appear in the representative sample and/or the sample as a whole.

- b. *Certain quality determinations.* Each determination of rodent pellets, bird droppings, other animal filth, broken glass, castor beans, cockleburs, crotonaria seeds, dockage, garlic, live insect infestation, large stones, moisture, temperature, an unknown foreign substance(s), and a commonly recognized harmful or toxic substance(s) is made on the basis of the sample as a whole. When a condition exists that may not appear in the representative sample, the determination may be made on the basis of the lot as a whole at the time of sampling according to procedures prescribed in FGIS instructions.
- c. *All other determinations.* The basis of determination for all other factors is contained in the standards for wheat.

### Percentages

- a. *Rounding.* Percentages are determined on the basis of weight and are rounded as follows:
  - (1) When the figure to be rounded is followed by a figure greater than or equal to 5, round to the next higher figure; e.g., report 6.36 as 6.4, 0.35 as 0.4, and 2.45 as 2.5.
  - (2) When the figure to be rounded is followed by a figure less than 5, retain the figure; e.g., report 8.34 as 8.3 and 1.22 as 1.2.
- b. *Recording.* The percentage of dockage in wheat is reported in whole and tenth percent to the nearest tenth percent. The percentage of ergot is reported to the nearest hundredth percent. The percentage when determining the identity of wheat is reported to the nearest whole percent. Also reported to the nearest whole percent are the classes and subclasses. All other percentages are reported in tenths percent.

## Grades, Grade Requirements, and Grade Designations

### Grades and Grade Requirements

The grades and grade requirements are shown in the grade table on page 24.

### Grade Designations

- a. *Grade designations for grain.* The grade designations include in the following order (1) the letters “U.S.”; (2) the abbreviation “No.” and the number of the grade or the words “Sample grade”; (3) when applicable, the subclass; (4) the class or kind of grain; (5) when appli-

cable, the special grade(s); and (6) when applicable, the word “dockage” together with the percentage thereof. When applicable, the remarks section of the certificate will include in the order of predominance; in the case of a mixed class, the name and approximate percentage of the classes; and if requested, the percentage of protein content.

- b. *Optional grade designations.* In addition to paragraph (a) of this section, grain may be certified under certain conditions as described in FGIS instructions when supported by official analysis as “U.S. No. 2 or better (type of wheat),” “U.S. No. 3 or better (type of wheat),” and the like.

## Special Grades, Special Grade Requirements, and Special Grade Designations

### Special Grades and Special Grade Requirements

A special grade serves to draw attention to a special factor or condition present in the grain and, when applicable, is supplemental to the grade assigned in subparagraphs (a) and (b) above. Except for the special grade “infested,” the special grades are identified and requirements are established in the standards for wheat.

- a. *Infested wheat.* Tolerances for live insects responsible for infested wheat are defined according to sampling designations as follows:
- (1) *Representative sample.* The representative sample consists of the work portion, and the file sample if needed and when available. These grains will be considered infested if the representative sample (other than shiplots) contains two or more live insects injurious to stored grain.
  - (2) *Lot as a whole (stationary).* The lot as a whole is considered infested when two or more live insects injurious to stored grain, or two or more other live insects injurious to stored grain are found in, on, or about the lot (excluding submitted samples and shiplots).
  - (3) *Sample as a whole (continuous loading/unloading of shiplots and bargelots).* The minimum sample size for bargelots and shiplots is 500 grams per each 2,000 bushels of grain. The sample as a whole is considered infested when a component (as defined in FGIS instructions) contains two or more live insects injurious to stored grain, or two or more other live insects injurious to stored grain.

### Special Grade Designations

Special grade designations are shown as prescribed in the section on grade designations. Multiple special grade designations will be listed in alphabetical order. In the case of treated wheat, the official certificate shall show whether the wheat has been scoured, limed, washed, sulfured, or otherwise treated.

## Wheat Terms Defined

### Definition of wheat

Grain that, before the removal of dockage, consists of 50 percent or more common wheat (*Triticum aestivum* L.), club wheat (*T. compactum* Host.), and durum wheat (*T. durum* Desf.) and not more than 10 percent of other grains for which standards have been established under the United States Grain Standards Act and that, after the removal of the dockage, contains 50 percent or more of whole kernels of one or more of these wheats.

### Definition of Other Terms

- a. *Classes.* There are eight classes for wheat: Durum wheat, Hard Red Spring wheat, Hard Red Winter wheat, Soft Red Winter wheat, Hard White wheat, Soft White wheat, Unclassed wheat, and Mixed wheat.
- (1) *Durum wheat.* All varieties of White (Amber) Durum wheat. This class is divided into the following three subclasses:
    - (i) *Hard Amber Durum wheat.* Durum wheat with 75 percent or more of hard and vitreous kernels of amber color.
    - (ii) *Amber Durum wheat.* Durum wheat with 60 percent or more but less than 75 percent of hard and vitreous kernels of amber color.
    - (iii) *Durum wheat.* Durum wheat with less than 60 percent of hard and vitreous kernels of amber color.
  - (2) *Hard Red Spring wheat.* All varieties of Hard Red Spring wheat. This class shall be divided into the following three subclasses:
    - (i) *Dark Northern Spring wheat.* Hard Red Spring wheat with 75 percent or more of dark, hard and vitreous kernels.
    - (ii) *Northern Spring wheat.* Hard Red Spring wheat with 25 percent or more but less than 75 percent of dark, hard, and vitreous kernels.



- (iii) *Red Spring wheat*. Hard Red Spring wheat with less than 25 percent of dark, hard, and vitreous kernels.
  - (3) *Hard Red Winter wheat*. All varieties of Hard Red Winter wheat. There are no subclasses in this class.
  - (4) *Soft Red Winter wheat*. All varieties of Soft Red Winter wheat. There are no subclasses in this class.
  - (5) *Hard White wheat*. All hard endosperm White wheat varieties. There are no subclasses in this class.
  - (6) *Soft White wheat*. All soft endosperm White wheat varieties. This class is divided into the following three subclasses:
    - (i) *Soft White wheat*. Soft endosperm White wheat varieties which contain not more than 10 percent of White Club wheat.
    - (ii) *White Club wheat*. Soft endosperm White Club wheat containing not more than 10 percent of other Soft White wheats.
    - (iii) *Western White wheat*. Soft White wheat containing more than 10 percent of White Club wheat and more than 10 percent of other Soft White wheats.
  - (7) *Unclassed wheat*. Any variety of wheat that is not classifiable under other criteria provided in the wheat standards. There are no subclasses in this class. This class includes any wheat which is other than red or white in color.
  - (8) *Mixed wheat*. Any mixture of wheat that consists of less than 90 percent of one class and more than 10 percent of one other class or a combination of classes that meet the definition of wheat.
- b. *Contrasting classes*. Contrasting classes are:
- (1) Durum wheat, Soft White wheat, and Unclassed wheat in the classes Hard Red Spring wheat and Hard Red Winter wheat.
  - (2) Hard Red Spring wheat, Hard Red Winter wheat, Hard White wheat, Soft Red Winter wheat, Soft White wheat, and Unclassed wheat in the class Durum wheat.
  - (3) Durum wheat and Unclassed wheat in the class Soft Red Winter wheat.
  - (4) Durum wheat, Hard Red Spring wheat, Hard Red Winter wheat, Soft Red Winter wheat, and Unclassed wheat in the classes Hard White wheat and Soft White wheat.
  - c. *Damaged kernels*. Kernels, pieces of wheat kernels, and other grains that are badly ground-damaged, badly weather-damaged, diseased, frost-damaged, germ-damaged, heat-damaged, insect-bored, mold-damaged, sprout-damaged, or otherwise materially damaged.
  - d. *Defects*. Damaged kernels, foreign materials, and shrunken and broken kernels. The sum of these three factors may not exceed the limit for the factor defects for each numerical grade.
  - e. *Dockage*. All matter other than wheat that can be removed from the original sample by use of an approved device according to procedures prescribed in FGIS instructions. Also, underdeveloped, shriveled, and small pieces of wheat kernels removed in properly separating the material other than wheat and that cannot be recovered by properly rescreening or recleaning.
  - f. *Foreign material*. All matter other than wheat that remains in the sample after the removal of dockage and shrunken and broken kernels.
  - g. *Heat-damaged kernels*. Kernels, pieces of wheat kernels, and other grains that are materially discolored and damaged by heat which remain in the sample after the removal of dockage and shrunken and broken kernels.
  - h. *Other grains*. Barley, canola, corn, cultivated buckwheat, einkorn, emmer, flaxseed, guar, hull-less barley, nongrain sorghum, oats, Polish wheat, popcorn, poulard wheat, rice, rye, safflower, sorghum, soybeans, spelt, sunflower seed, sweet corn, triticale, and wild oats.
  - i. *Shrunken and broken kernels*. All matter that passes through a  $0.064 \times \frac{3}{8}$ -inch oblong-hole sieve after sieving according to procedures prescribed in the FGIS instructions.
  - j. *Sieve- $0.064 \times \frac{3}{8}$  inch (1.626 mm  $\times$  9.545 mm), oblong-hole sieve*. A metal sieve 0.032 inch thick with oblong perforations 0.064 inch by 0.375 ( $\frac{3}{8}$ ) inch.

# Principles Governing the Application of Standards

## Basis of determination

Each determination of heat-damaged kernels, damaged kernels, foreign material, wheat of other classes, contrasting classes, and subclasses is made on the basis of the grain

when free from dockage and shrunken and broken kernels. Other determinations not specifically provided for under the general provisions are made on the basis of the grain when free from dockage, except the determination of odor is made on either the basis of the grain as a whole or the grain when free from dockage.

## Grades and Grade Requirements

<b>WHEAT</b>					
§810.2204(a) - Grades and Grade Requirements					
Grading Factors	Grades U.S. Nos				
	1	2	3	4	5
<b>Minimum pound limits of:</b>					
Test Weight					
Hard Red Spring Wheat or White Club wheat lbs/bu (Kg/hl)	58.0 (76.4)	57.0 (75.1)	55.0 (72.5)	53.0 (69.9)	50.0 (66.0)
Durum lbs/bu (Kg/hl)	60.0 (78.2)	58.0 (75.6)	56.0 (73.0)	54.0 (70.4)	51.0 (66.5)
All other classes and subclasses lbs/bu (Kg/hl)	60.0 (78.9)	58.0 (76.4)	56.0 (73.8)	54.0 (71.2)	51.0 (67.3)
<b>Maximum percent limits of:</b>					
<b>Defects</b>					
Damaged kernels					
Heat (part of total)	0.2	0.2	0.5	1.0	3.0
Total	2.0	4.0	7.0	10.0	15.0
Foreign material	0.4	0.7	1.3	3.0	5.0
Shrunken & broken kernels	3.0	5.0	8.0	12.0	20.0
Total <sup>1</sup>	3.0	5.0	8.0	12.0	20.0
<b>Wheat of other classes<sup>2</sup></b>					
Contrasting classes	1.0	2.0	3.0	10.0	10.0
Total <sup>3</sup>	3.0	5.0	10.0	10.0	10.0
<b>Stones</b>					
	0.1	0.1	0.1	0.1	0.1
<b>Maximum count limit of:</b>					
Other material					
Animal filth	1	1	1	1	1
Castor beans	1	1	1	1	1
Crotalaria seeds	2	2	2	2	2
Glass	0	0	0	0	0
Stones	3	3	3	3	3
Unknown foreign substance	3	3	3	3	3
Total <sup>4</sup>	4	4	4	4	4
<b>Insect-damaged kernels in 100 grams</b>	31	31	31	31	31
U.S. Sample grade					
Wheat that:					
(a) Does not meet the requirements for U.S. Nos. 1, 2, 3, 4, or 5; or					
(b) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor) or					
(c) Is heating or of distinctly low quality					
<sup>1</sup> Includes damaged kernels (total), foreign material, and shrunken and broken kernels					
<sup>2</sup> Unclassed wheat of any grade may contain not more than 10.0 percent of wheat of other classes.					
<sup>3</sup> Includes contrasting classes					
<sup>4</sup> Includes any combination of animal filth, castor beans, crotalaria seeds, glass, stones, or unknown foreign substance.					

\*The metric equivalent on test weight has been added as a service for international readers. The U.S. official grade chart is given only in pounds per bushel.

### **Grades and Grade Requirements for Mixed Wheat**

Mixed wheat is graded according to the U.S. Numerical and U.S. Sample grade requirements of the class of wheat that predominates in the mixture, except that the factor wheat of other classes is disregarded.

### **Special Grades and Special Grade Requirements**

- a. *Ergoty wheat.* Wheat that contains more than 0.05 percent of ergot.

Example: U.S. No. 2 Hard Red Winter wheat, Ergoty, Dockage 0.3 percent

- b. *Garlicky wheat.* Wheat that contains in a 1,000-gram portion more than two green garlic bulblets or an equivalent quantity of dry or partly dry bulblets.

Example: U.S. No. 2 Soft Red Winter wheat, Garlicky, Dockage 0.6 percent

- c. *Light smutty wheat.* Wheat that has an unmistakable odor of smut, or which contains in a 250-gram portion, smut balls, portions of smut balls, or spores of smut in excess of a quantity equal to 5 smut balls, but not in excess of a quantity equal to 30 smut balls of average size.

Example: U.S. No. 3 Hard Red Winter wheat, Light Smutty, Dockage 0.5 percent

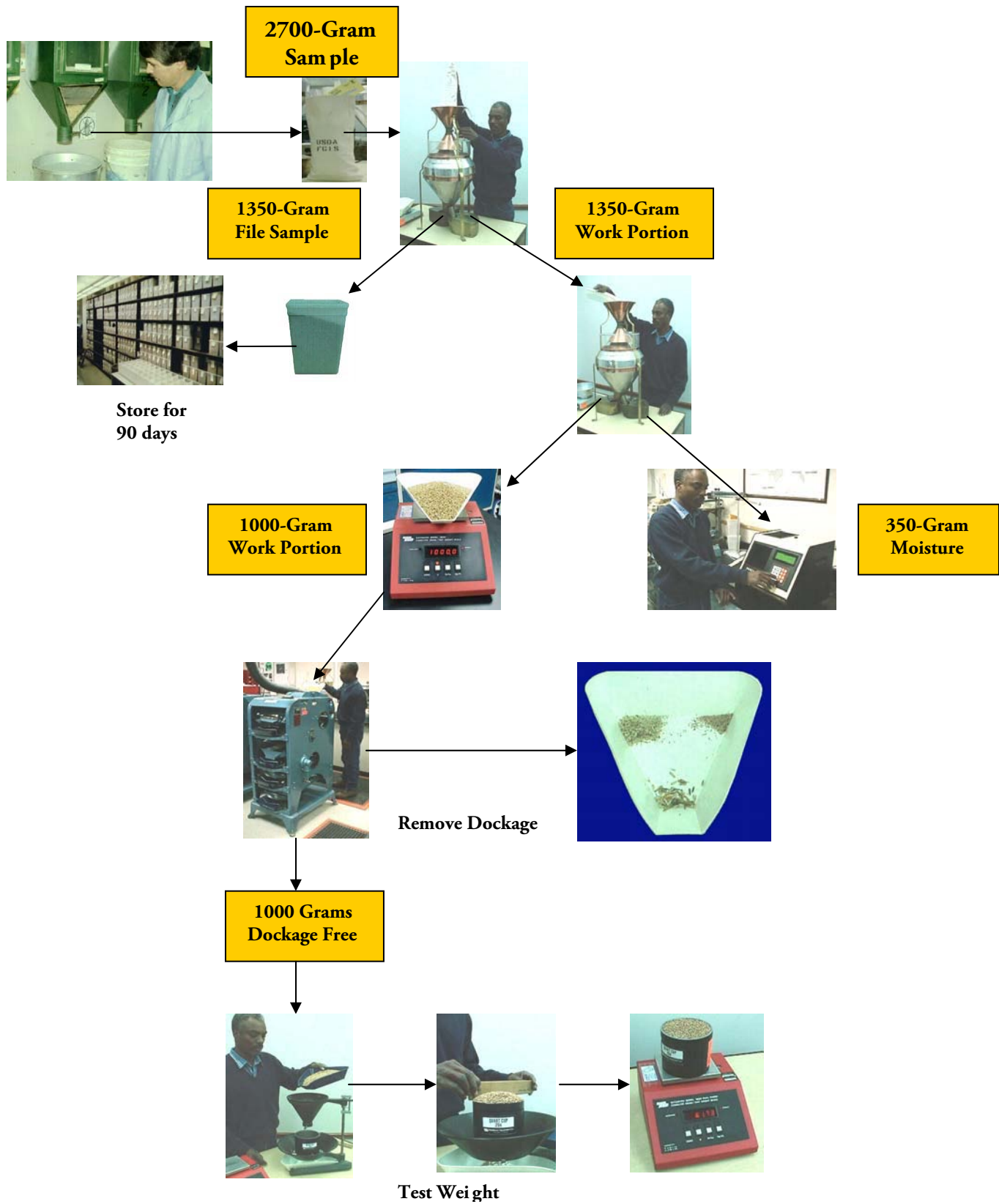
- d. *Smutty wheat.* Wheat that contains, in a 250-gram portion, smut balls, portions of smut balls, or spores of smut in excess of a quantity equal to 30 smut balls of average size.

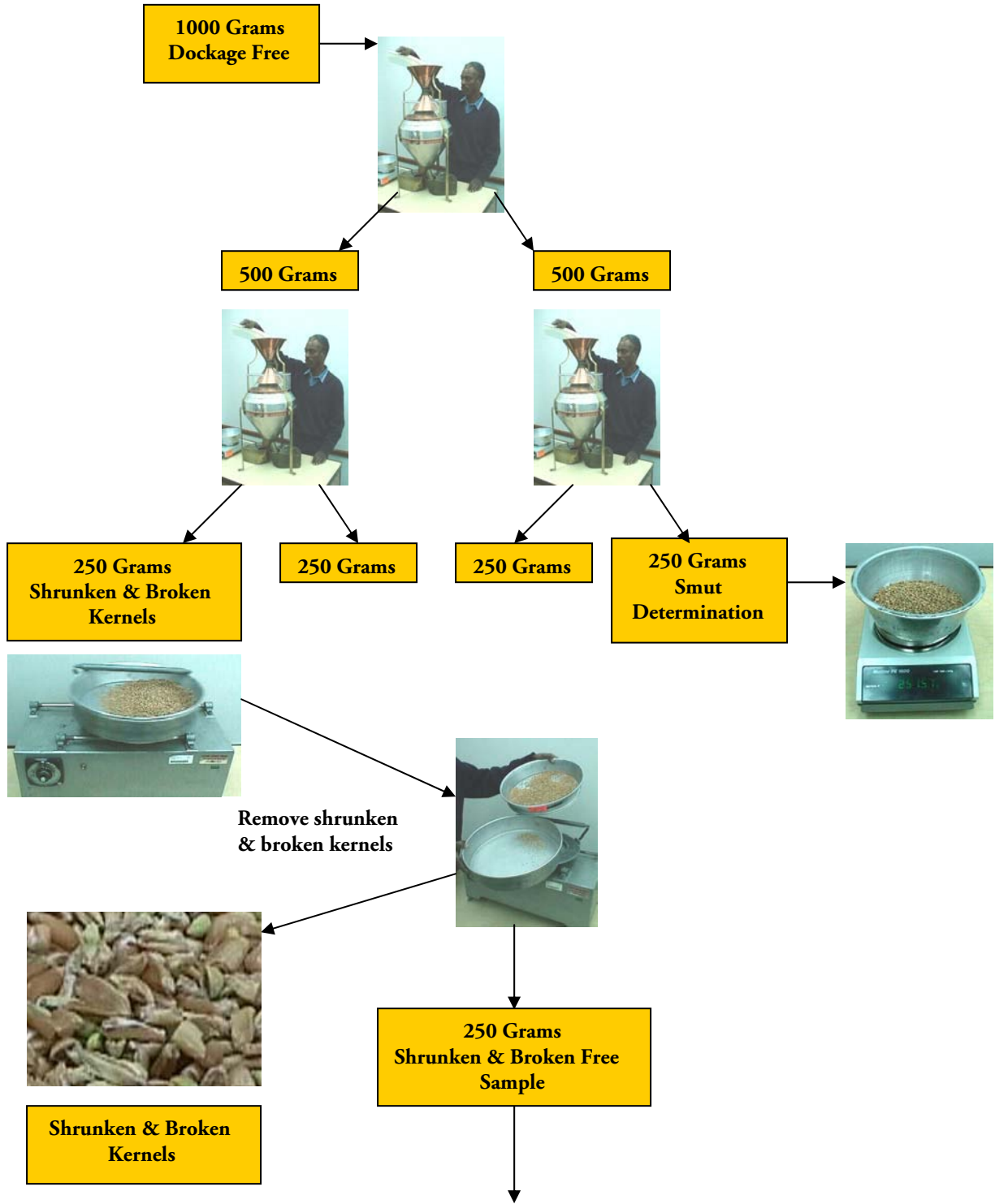
Example: U.S. No. 2 Northern Spring wheat, Smutty, Dockage 0.5 percent

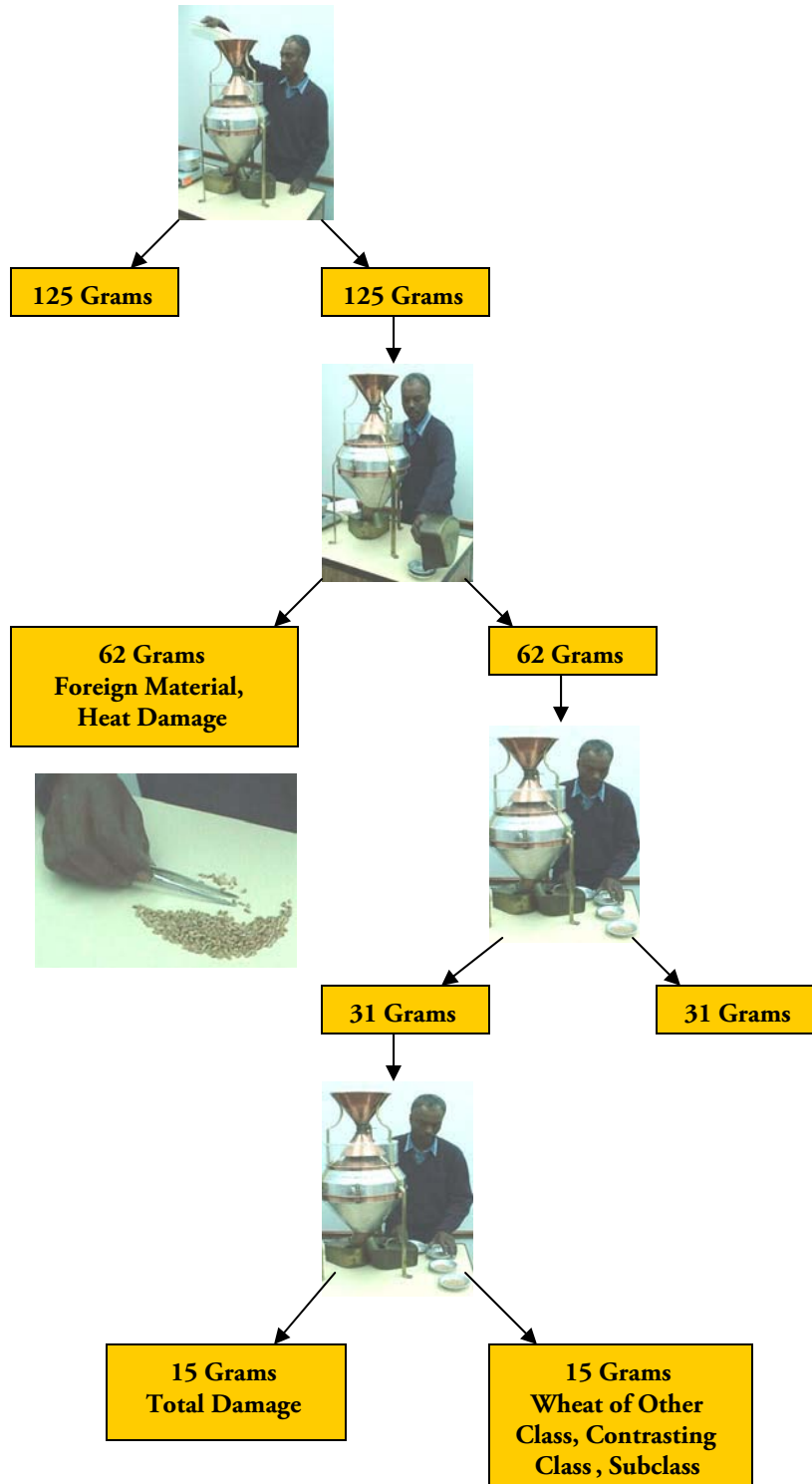
- e. *Treated wheat.* Wheat that has been scoured, limed, washed, sulfured, or treated in such a manner that the true quality is not reflected by either the numerical grades or the U.S. sample grade designation alone.

Example: U.S. No. 1 Amber Durum wheat, Treated (limed), Dockage 0.2 percent

# Wheat Sample Breakdown Chart







# *Section 3: Wheat and Milling Tests*

---

<i>Moisture Content</i> .....	30
<i>Ash Content</i> .....	31
<i>Protein Content</i> .....	32
<i>Falling Number</i> .....	33
<i>Thousand Kernel Weight</i> .....	34
<i>Sedimentation</i> .....	35
<i>Deoxynivalenol (DON) – Lateral Flow Strip</i> .....	36
<i>Single Kernel Characterization System (SKCS)</i> .....	37
<i>Laboratory Wheat Milling</i> .....	38
<i>Simplified Milling Process Diagram</i> .....	40

## Moisture Content

### Method

1. A small sample of flour or ground wheat (2 to 3 grams) is weighed and placed in a moisture dish.
2. The sample is heated at 130 degrees Celsius in an air oven for 1 hour.
3. The sample is cooled to room temperature and the residue is weighed.

### Results

- Moisture content is determined by heating a flour or ground wheat sample in an air oven and comparing the weight of the sample before and after heating.
- The amount of weight loss is the moisture content.
- Moisture content results are expressed as a percentage. An example of a wheat moisture content is 12 percent.

### Why is this important?

Determining moisture content is an essential first step in analyzing wheat or flour quality since this data is used for other tests. Flour millers adjust the moisture in wheat to a standard level before milling. Moisture content of 14 percent is commonly used as a conversion factor for other tests in which the results are affected by moisture content.

Moisture is also an indicator of grain storability. Wheat or flour with high moisture content (greater than 14.5 percent) attracts mold, bacteria, and insects, all of which cause dete-



*Sample dishes in moisture oven.*

rioration during storage. Wheat or flour with low moisture content is more stable during storage.

Moisture content can be an indicator of profitability in milling. Flour is sold by weight, grain is bought by weight, and water is added to reach the standard moisture level before milling. The more water added, the more weight and profitability gained from the wheat. Wheat with too low moisture, however, may require special equipment or processes before milling to reach the standard moisture level.

Other methods of determining moisture content are used in the industry. For example, Federal Grain Inspection Service (FGIS) uses the GAC 2100 to measure moisture content of whole wheat kernels.

*Adapted from Method 44-15A, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*

- 
- **Low temperature heating**
  - **Measures moisture content**
-



## Ash Content

### Method

1. A sample of flour or ground wheat (3 to 5 grams) is weighed and placed in an ash cup.
2. The sample is heated at 585 degrees Celsius in an ash oven until its weight is stable (usually overnight).
3. The residue is cooled to room temperature and then weighed.

### Results

- Ash content is determined by high temperature incineration in an electric muffle furnace.
- When a sample is incinerated in an ash oven, the high temperature drives out the moisture and burns away all the organic materials (starch, protein, and oil), leaving only the ash. The residue (ash) is composed of the non-combustible, inorganic minerals that are concentrated in the bran layer.
- Ash content results for wheat or flour ash are expressed as a percentage of the initial sample weight; for example, wheat ash of 1.58 percent or flour ash of 0.52 percent. Wheat or flour ash is usually expressed on a common moisture basis of 14 percent.

### Why is this important?

The ash content in wheat and flour has significance for milling. Millers need to know the overall mineral content of the wheat to achieve desired or specified ash levels in flour. Since ash is primarily concentrated in the bran, ash content in flour is an indication of the yield that can be expected during milling. Ash content also indicates milling performance by indirectly revealing the amount of bran contamination in flour. Ash in flour can affect color, imparting a darker color to finished products. Some specialty products requiring



*Ash crucibles and furnace.*

particularly white flour call for low ash content while other products, such as whole wheat flour, have a high ash content.

*Adapted from Method 08-01, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*

- 
- **High temperature incineration**
  - **Measures mineral (ash) content**
-

## Protein Content

Combustion Nitrogen Analyses (CNA) is one of several methods used to determine protein content in flour or wheat.

### Method

1. A sample of flour or ground wheat (0.15 to 0.20 grams) is weighed and placed into a CNA protein analyzer.
2. This process is fully automated and begins by dropping the sample into a hot oven where it is burned at 952 degrees Celsius.
3. The amount of nitrogen gas released during burning is measured and a formula is applied to convert this measurement to protein content in the sample.

### Results

- Protein content is determined through high temperature combustion in a protein analyzer. Since protein is the major wheat compound that contains nitrogen, the protein content can be determined by measuring the amount of nitrogen released during burning.
- Protein content results are expressed as a percentage of the total sample weight; for example, 10 percent protein content on 12 percent moisture basis for wheat or 8.5 percent on 14 percent moisture basis for flour.

### Why is this important?

Protein content is a key specification for wheat and flour purchasers since it is related to many processing properties, such as water absorption and gluten strength. Protein content also can be related to finished-product attributes, such as texture and appearance. Low protein content is desired for crisp or tender products, such as snacks or cakes. High protein content is desired for products with chewy texture, such as pan bread and hearth bread.

Bakers use protein content results to anticipate water absorption and dough development time for processes and products, because higher protein content usually requires more water and a longer mixing time to achieve optimum dough consistency.



*Combustion Nitrogen Analysis machine.*

Combustion Nitrogen Analysis (CNA) is often used to develop calibrations for other protein methods, such as Near Infrared Transmittance (NIRT) or Near Infrared Reflectance (NIRR).

*Adapted from Method 46-30, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*

- 
- **High temperature combustion**
  - **Measures protein content**
-

# Falling Number

## Method

1. A 7-gram sample of ground wheat or flour is weighed and combined with 25 milliliter of distilled water in a glass falling number tube with a stirrer and shaken to form a slurry. When grinding a wheat sample to perform a falling number test, it should be at least 300 grams to assure a representative sample
2. As the slurry is heated in a boiling water bath at 100 degrees Celsius and stirred constantly, the starch gelatinizes and forms a thick paste.
3. The time it takes the stirrer to drop through the paste is recorded as the falling number value.

## Results

- The falling number instrument analyzes viscosity by measuring the resistance of a flour-and-water paste to a falling stirrer.
- Falling number results are recorded as an index of enzyme activity in a wheat or flour sample and the results are expressed in time as seconds.
- A high falling number (for example, above 300 seconds) indicates minimal enzyme activity and sound quality wheat or flour.
- A low falling number (for example, below 250 seconds) indicates substantial enzyme activity and sprout-damaged wheat or flour.

## Why is this important?

The level of enzyme activity measured by the falling number test affects product quality. Yeast in bread dough, for example, requires sugars to develop properly and therefore needs some level of enzyme activity in the dough. Too much enzyme activity, however, means that too much sugar and too little starch are present. Since starch provides the supporting structure of bread, too much activity results in sticky dough during processing and poor texture in the finished product. If the falling number is too high, enzymes can be added to the



*Falling number apparatus.*

flour in various ways to compensate. If the falling number is too low, enzymes cannot be removed from the flour or wheat, which results in a serious problem that makes the flour unusable.

*Adapted from Method 56-81B, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000, St. Paul, MN.*

- 
- **Viscosity analysis**
  - **Measures the effects of sprout damage**
-

# Thousand Kernel Weight

## Method

1. Prepare a 500-gram sample of wheat by removing all dockage, shrunken and broken kernels, and other foreign material.
2. Divide the sample several times using a mechanical divider until you have approximately 50 grams.
3. Count 1,000 kernels using a mechanical counter and weigh.

## Results

- Thousand kernel weight is the weight in grams of 1,000 kernels of wheat.
- This method is used to estimate kernel mass.
- This measurement also may be determined using the Single Kernel Characterization System.

## Why is this important?

Thousand kernel weight (TKW), as a method, measures the mass of the wheat kernel. It is used by wheat breeders and flour millers as a complement to test weight to better describe wheat kernel composition and potential flour extraction. Generally speaking, wheat with a higher TKW can be expected to have a greater potential flour extraction.



## Sedimentation

### Method

1. A small sample of flour or ground wheat (3.2 grams) is weighed and placed in 100-milliliter glass-stoppered graduated cylinder.
2. Water (50 milliliter) is added to the cylinder and mixed for 5 minutes.
3. Lactic acid solution is added to the cylinder and mixed for 5 minutes.
4. The cylinder is removed from the mixer and kept in upright position for 5 minutes.
5. The sedimentation volume is recorded.

### Results

- The sedimentation test is conducted by holding the ground wheat or flour sample in an acid solution.
- During the sedimentation test gluten proteins of ground wheat or flour swells and precipitate as a sediment.
- Sedimentation values can be in the range of 20 or less for low-protein wheat with weak gluten to as high as 70 or more for high-protein wheat with strong gluten.

### Why is this important?

- The sedimentation test provides information on the protein quantity and the quality of ground wheat and flour samples. Positive correlations were observed between sedimentation volume and gluten strength or loaf volume attributes. The sedimentation test is used as a screening tool in wheat breeding as well as in milling applications.

*Adapted from Method 56-61A, Approved Methods of the American Association of Cereal Chemists, 10<sup>th</sup> Edition. 2000. St. Paul, MN.*



*Sedimentation cylinders.*

## Deoxynivalenol (DON) – Lateral Flow Strip

### Method

Levels of deoxynivalenol (DON), also referred to as vomitoxin, are measured in the marketing channels with commercially available test kits. Test kits are based on immunochemical technology. GIPSA tests and approves mycotoxin test kits, including DON, for use in the U.S. official inspection system. These kits must meet GIPSA accuracy and precision requirements when compared to HPLC reference methods in order to be approved.

### General

1. Prepare sample by weighing a portion sample of ground wheat and mixing the ground wheat sample with distilled water and shake.
2. Dilute the mixture as directed by the manufacturer's directions
3. Place test strip in incubator, peel back the tape, and add a portion of the diluted solution.
4. Close the lid of the incubator and wait.
5. Evaluate the results according to the manufacturer's directions.

### Results

- The lateral flow strips used in test kits provide a yes or no answer to whether the sample tested contains DON above a certain amount.
- Usually within 5 to 15 minutes the results can be read.
- All tests include an internal procedural control line that is used to validate the test result.
- The appearance of two lines indicates a positive result, while a negative test produces only one line.

### Why is this important?

DON is a toxin produced by fusarium fungi. DON occurs in feed grains when grown under certain climatic conditions. Illnesses have been observed in livestock that have consumed feed grains containing high levels of DON concentrations.



*DON lateral test strips and HPLC vials.*

- **Quick test**
- **Detects levels of vomitoxin**

## Single-Kernel Characterization System (SKCS)

### Method

1. A sample of wheat kernels (12 to 16 grams) is prepared by removing broken kernels, weed seeds, and other foreign material.
2. The sample is poured into the access hopper of the single-kernel characterization system instrument.
3. The SKCS instrument analyzes 300 kernels individually and records the results on a computer graph.

### Results

- Wheat kernel characteristics are analyzed for: kernel weight by load cell, kernel diameter and moisture content by electrical current, and kernel hardness by pressure force.
- Averages and standard deviations of these parameters are reported as SKCS results in terms of values: kernel weight is expressed in milligrams (mg); kernel diameter is expressed in millimeters (mm); moisture content is expressed as a percentage; and kernel hardness is expressed as an index of -20 to 120.

### Why is this important?

The single-kernel characterization system test evaluates wheat kernel texture characteristics by measuring the weight, electrical current, and force needed to crush the kernels. Kernel characteristics are related to important milling properties, such as conditioning (tempering), roll gap settings, and flour starch damage content.

*Adapted from Method 55-31, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*



*SKCS analyzer.*

- 
- **Kernel analysis**
  - **Measures kernel characteristics**
-

# Laboratory Wheat Milling

## Method

1. A sample of wheat is cleaned and the moisture content is determined.
2. Water is added to condition (temper) the wheat overnight prior to milling. Soft wheat requires less water and less time than hard wheat.
3. The tempered wheat sample is run through the mill the following day.
4. The mill fractions, such as flour streams, bran, and shorts, are weighed and recorded.

## Results

- Wheat samples are milled to evaluate wheat milling properties, including flour extraction and the amount of non-flour components produced, such as bran and shorts.
- Laboratory flour mill results are generally expressed as the weight of flour, bran, and shorts. Often, flour extraction is reported as a percentage of flour compared to the total output of other mill products; however extraction could be reported as the percentage of flour from the sample of wheat milled.
- Flour produced can be used for other tests.

## Why is this important?

Laboratory flour milling tests indicate milling properties on small wheat samples. Commercial flour mills can use this information to adjust mill settings and optimize flour extraction.

Small samples of wheat can be milled on a number of different laboratory mills to produce flour. This flour is used to evaluate properties, such as ash and protein content, and in gluten strength tests, such as the farinograph. The most common laboratory mills are the Brabender Quadramat Flour Mills and the Buhler Laboratory Flour Mill.

The Brabender Quadramat is available in two models, the Quad Jr. and the Quad Sr. Both mills use a series of three rolls to grind the wheat. The main difference between the two models is the Quad Jr. is a single pass machine and the Quad Sr. has a double pass grinding flow.

- **Laboratory-scale flour mill**
- **Determines flour yield and makes flour for other tests**



*Buhler MLU-202 laboratory mill.*

Both models are best used for as micro-milling or the milling of very small samples.

Micro-milling is important for wheat breeding programs. Early generation wheat varieties need to be tested for milling and baking qualities, but very small samples are available for testing. Samples as small as 50 grams can be processed using either of the Quadramat milling systems.

The normal sample size is 100 grams to produce enough flour for further analysis.

The Buhler Laboratory Flour Mill is the most common laboratory mill used by milling companies and grain quality

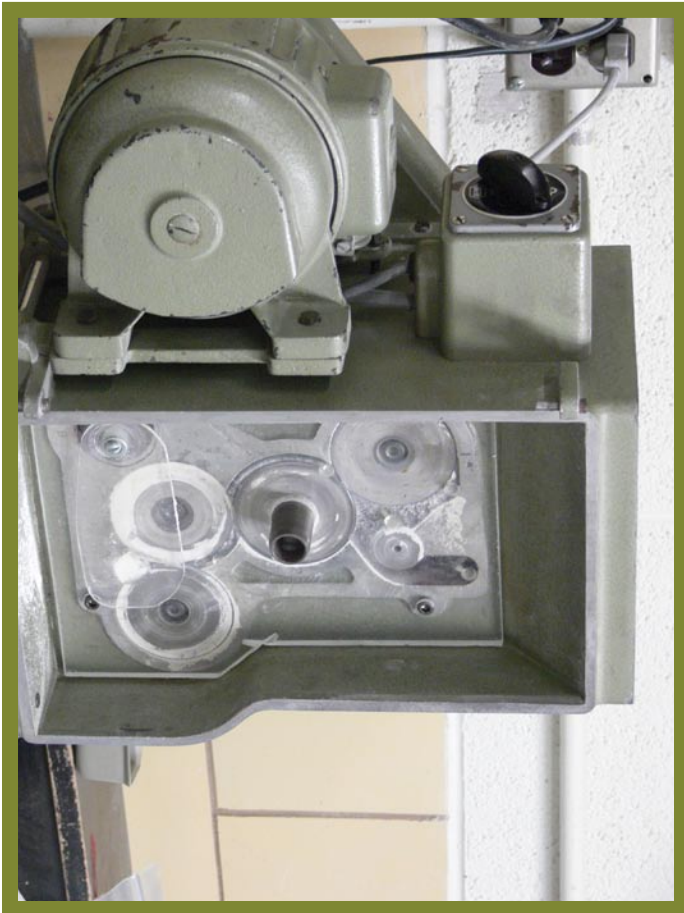


laboratories to evaluate commercial wheat samples. The Buhler Laboratory mill has six grinding passages, three fluted roll break passages and three smooth roll reduction passages. This mill operates at about 125 grams per minutes and can handle much larger samples, commonly up to five kilograms. The larger sample size produces sufficient flour to run additional flour functionality tests such as the farinograph and alveograph and product test baking.

*Adapted from Methods 26-21A, 26-30A, 26-31, 26-41, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*



*Brabender Qudramat Sr. laboratory mill.*



*Brabender Quadramat Jr. laboratory mill.*

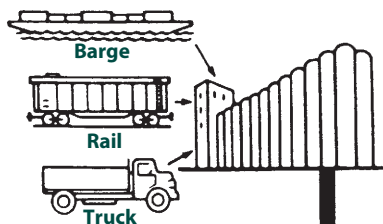


*Brabender Qudramat Sr. grinding rolls.*

# Simplified Milling Process Diagram

*This flow diagram is greatly simplified. The sequence, number, and complexity of operations vary in different mills.*

It starts here . . .



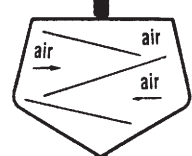
**Elevator**  
Storage and care of wheat.



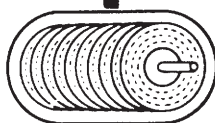
**Product Control**  
Chemists inspect and classify wheat. Blending is often done at this point.



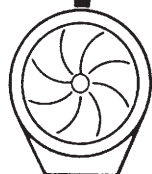
**Separator**  
Reciprocating screens remove stones, sticks, and other coarse or fine materials.



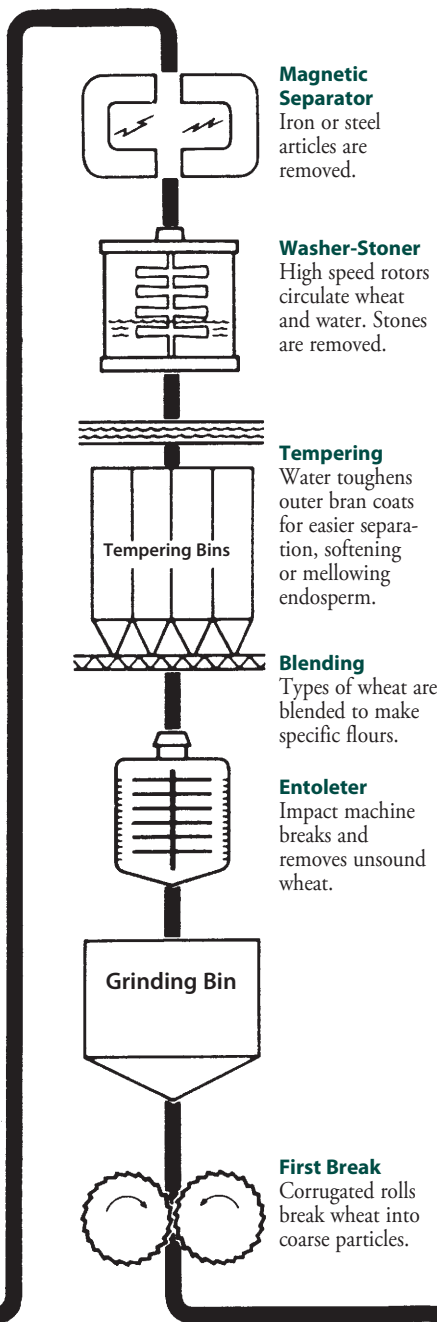
**Aspirator**  
Air currents remove lighter impurities.



**Disc Separator**  
Barley, oats, cockle, and other foreign materials are removed.



**Scourer**  
Beaters in screen cylinder scour off impurities and roughage.



**Magnetic Separator**  
Iron or steel articles are removed.

**Washer-Stoner**  
High speed rotors circulate wheat and water. Stones are removed.

**Tempering**  
Water toughens outer bran coats for easier separation, softening or mellowing endosperm.

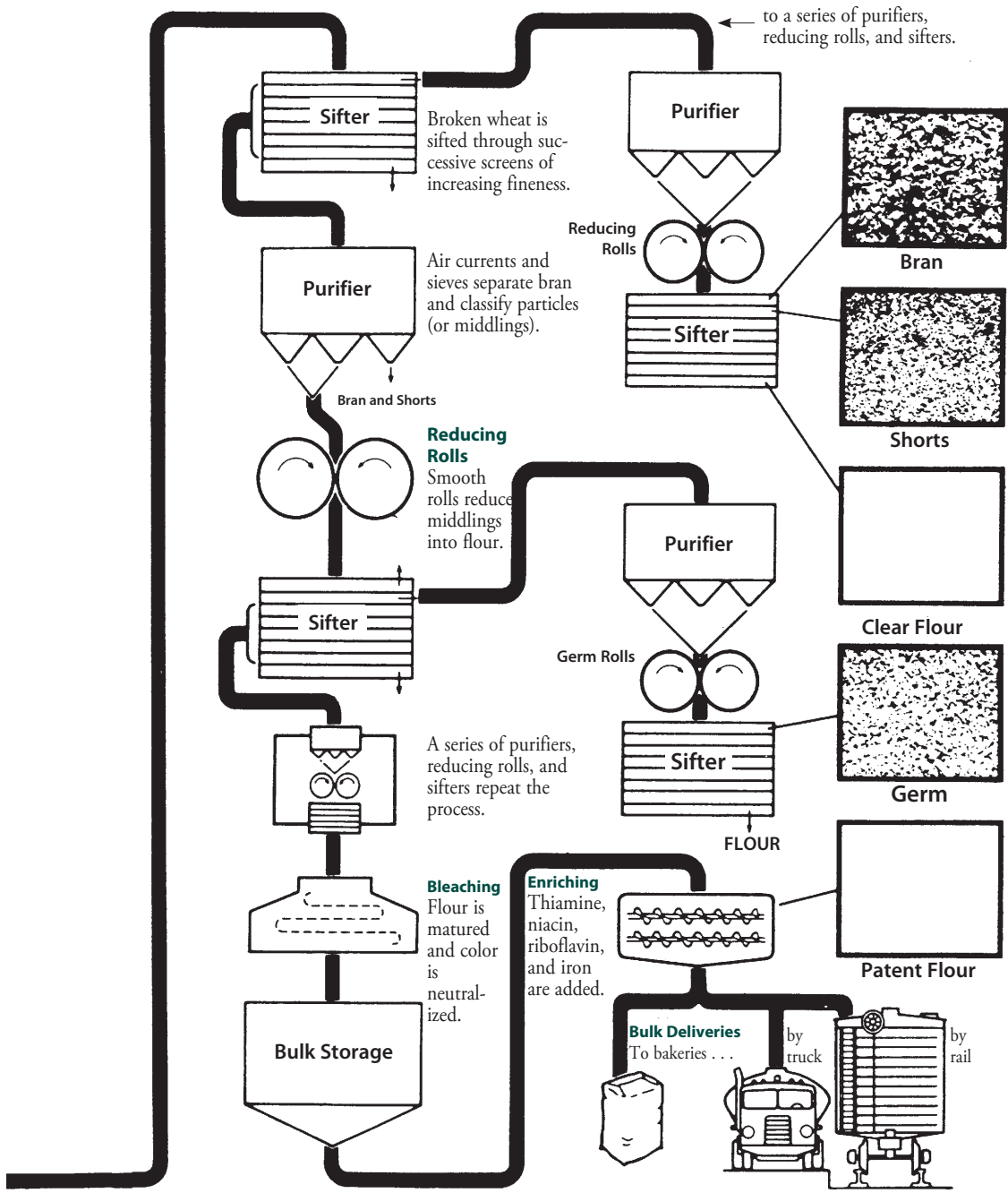
**Blending**  
Types of wheat are blended to make specific flours.

**Entoleter**  
Impact machine breaks and removes unsound wheat.

**Grinding Bin**

**First Break**  
Corrugated rolls break wheat into coarse particles.

Courtesy of Wheat Foods Council, 10841 S. Crossroads Drive, Suite 105, Parker, Colorado 80138.



# *Section 4: Flour and Dough Tests*

---

<i>Falling Number</i> .....	43
<i>Flour Color Analysis</i> .....	44
<i>Farinograph</i> .....	45
<i>Extensigraph</i> .....	47
<i>Alveograph</i> .....	49
<i>Mixograph</i> .....	51
<i>Glutomatic</i> .....	53
<i>Amylograph</i> .....	54
<i>Rapid Visco Analyzer</i> .....	56
<i>Solvent Retention Capacity (SRC)</i> .....	57

# Falling Number

## Method

1. A 7-gram sample of ground wheat or flour is weighed and combined with 25 milliliter of distilled water in a glass falling number tube with a stirrer and shaken to form a slurry. When grinding a wheat sample to perform a falling number test, it should be at least 300 grams to assure a representative sample
2. As the slurry is heated in a boiling water bath at 100 degrees Celsius and stirred constantly, the starch gelatinizes and forms a thick paste.
3. The time it takes the stirrer to drop through the paste is recorded as the falling number value.

## Results

- The falling number instrument analyzes viscosity by measuring the resistance of a flour-and-water paste to a falling stirrer.
- Falling number results are recorded as an index of enzyme activity in a wheat or flour sample and the results are expressed in time as seconds.
- A high falling number (for example, above 300 seconds) indicates minimal enzyme activity and sound quality wheat or flour.
- A low falling number (for example, below 250 seconds) indicates substantial enzyme activity and sprout-damaged wheat or flour.

## Why is this important?

The level of enzyme activity measured by the falling number test affects product quality. Yeast in bread dough, for example, requires sugars to develop properly and therefore needs some level of enzyme activity in the dough. Too much enzyme activity, however, means that too much sugar and too little starch are present. Since starch provides the supporting structure of bread, too much activity results in sticky dough during processing and poor texture in the finished product. If the falling number is too high, enzymes can be added to the



*Falling number apparatus.*

flour in various ways to compensate. If the falling number is too low, enzymes cannot be removed from the flour or wheat, which results in a serious problem that makes the flour unusable.

*Adapted from Method 56-81B, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000., St. Paul, MN.*

- 
- **Viscosity analysis**
  - **Measures the effects of sprout damage**
-

## Flour Color Analysis

One method used to measure flour color is the Minolta Chroma Meter Test.

### Method

1. A sample of flour is placed on the granular materials attachment and compacted.
2. The Minolta Chroma Meter is inserted into the granular materials attachment.
3. Measurements are taken and recorded.

### Results

- Flour color is determined by measuring the whiteness of a flour sample with the Minolta Chroma Meter.
- Flour color results are reported in terms of 3-dimensional color values based on the following rating scale:

L* value	whiteness	100 white
		0 black
a* value	positive values	+60 red color
	negative values	-60 green color
b* value	positive values	+60 yellow color
	negative values	-60 blue color

- The color values of a typical white flour, for example, are:

L\* value +92.5 whiteness

a\* value -2.4 green color

b\* value +6.9 yellow color



*Minolta color meter and color chart.*

### Why is this important?

Flour color often affects the color of the finished product and is therefore one of many flour specifications required by end-users. Generally speaking, a bright white color flour is more desirable for many products.

*Adapted from Minolta Chroma Meter CR-310 Instruction Manual, Minolta Camera Co., Ltd. 1991.*

## ■ Color analysis

## ■ Measures flour color

# Farinograph

## Method

1. A flour sample of 50 or 300 grams on a 14 percent moisture basis is weighed and placed into the corresponding farinograph mixing bowl.
2. Water from a buret is added to the flour and mixed to form a dough.
3. As the dough is mixed, the farinograph records a curve on graph paper.
4. The amount of water added (absorption) affects the position of the curve on the graph paper. Less water increases dough consistency and moves the curve upward.
5. The curve is centered on the 500-Brabender unit (BU) line  $\pm 20$  BU by adding the appropriate amount of water and is run until the curve leaves the 500-BU line.

## Results

- The farinograph determines dough and gluten properties of a flour sample by measuring the resistance of a dough against the mixing action of paddles (blades).
- Farinograph results include absorption, arrival time, stability time, peak time, departure time, and mixing tolerance index.
- Farinograph curves are described on pages 30 to 31.

## Why is this important?

The farinograph test is one of the most commonly used flour quality tests in the world. The results are used as parameters in formulation to estimate the amount of water required to make a dough, to evaluate the effects of ingredients on mixing properties, to evaluate flour blending requirements, and to check flour uniformity. The results are also used to predict processing effects, including mixing requirements for dough development, tolerance to over-mixing, and dough



*Farinograph mixer and apparatus.*

consistency during production. Farinograph results are also useful for predicting finished product texture characteristics. For example, strong dough mixing properties are related to firm product texture.

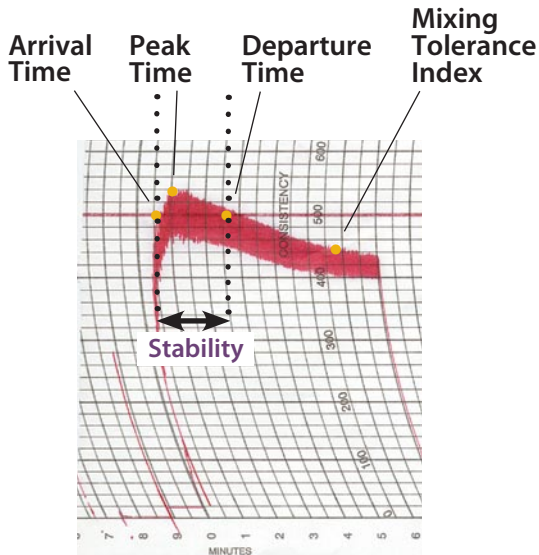
- 
- **Recording dough mixer**
  - **Measures flour water absorption and dough strength**
-

The farinograph test measures and records the resistance of a dough to mixing with paddles.

- **Absorption** is the amount of water required to center the farinograph curve on the 500-Brabender unit (BU) line. This relates to the amount of water needed for a flour to be optimally processed into end products. Absorption is expressed as a percentage.
- **Peak Time** indicates dough development time, beginning the moment water is added until the dough reaches

maximum consistency. This gives an indication of optimum mixing time under standardized conditions. Peak time is expressed in minutes.

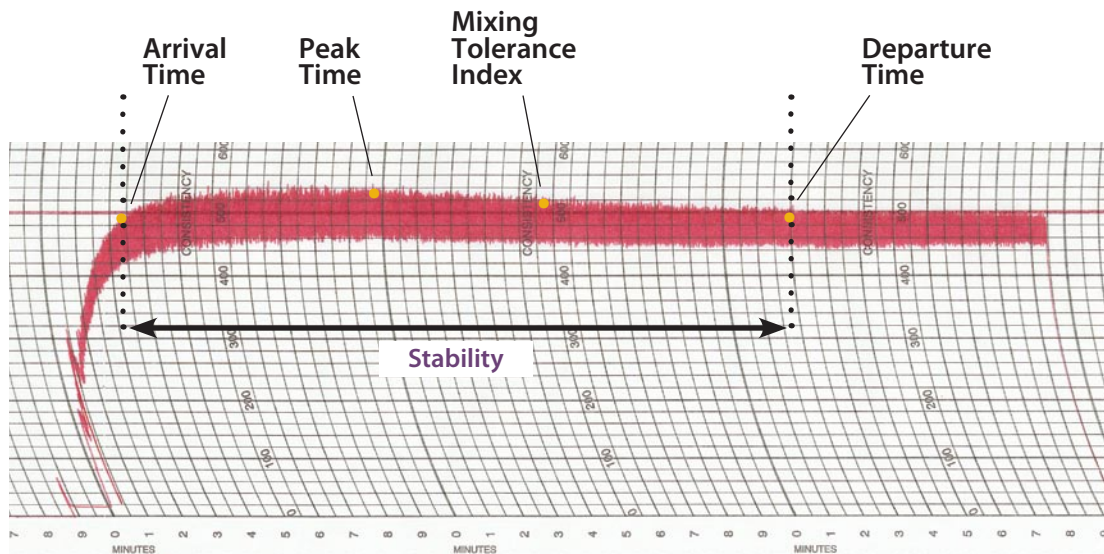
- **Arrival Time** is the time when the top of the curve touches the 500-BU line. This indicates the rate of flour hydration (the rate at which the water is taken up by the flour). Arrival time is expressed in minutes.
- **Departure Time** is the time when the top of the curve leaves the 500-BU line. This indicates the time when the dough is beginning to break down and is an indication of dough consistency during processing. Departure time is expressed in minutes.
- **Stability Time** is the difference in time between arrival time and departure time. This indicates the time the dough maintains maximum consistency and is a good indication of dough strength. Stability time is expressed in minutes.
- **Mixing Tolerance Index (MTI)** is the difference in BU value at the top of the curve at peak time and the value at the top of the curve 5 minutes after the peak. This indicates the degree of softening during mixing. Mixing tolerance index is expressed in Brabender units (BU).



Weak gluten flour has a lower water absorption and shorter stability time than strong gluten flour.

## Weak Gluten Flour

*Adapted from Method 54-21, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*



## Strong Gluten Flour



# Extensigraph

## Method

### Preparation

1. A 300-gram flour sample on a 14 percent moisture basis is combined with a salt solution and mixed in the farinograph to form a dough.
2. After the dough is rested for 5 minutes, it is mixed to maximum consistency (peak time).

### Analyses

1. A 150-gram sample of prepared dough is placed on the extensigraph rounder and shaped into a ball.
2. The ball of dough is removed from the rounder and shaped into a cylinder.
3. The dough cylinder is placed into the extensigraph dough cradle, secured with pins, and rested for 45 minutes in a controlled environment.
4. A hook is drawn through the dough, stretching it downwards until it breaks.
5. The extensigraph records a curve on graph paper as the test is run.
6. The same dough is shaped and stretched two more times, at 90 minutes and at 135 minutes.

## Results

- The extensigraph determines the resistance and extensibility of a dough by measuring the force required to stretch the dough with a hook until it breaks.
- Extensigraph results include resistance to extension, extensibility, and area under the curve.
- Resistance to extension is a measure of dough strength. A higher resistance to extension requires more force to stretch the dough.
- Extensibility indicates the amount of elasticity in the dough and its ability to stretch without breaking.
- Extensigraph curves are described on pages 48.

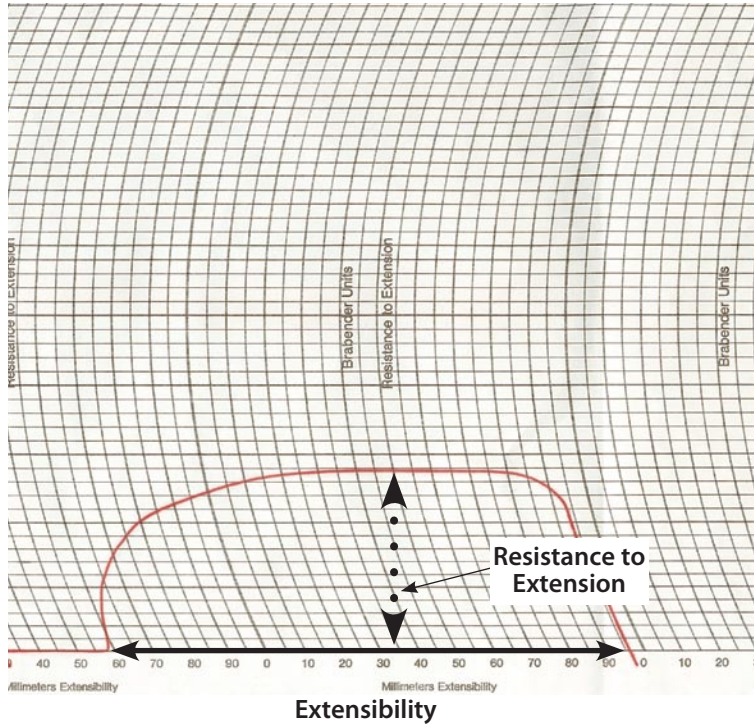


*Dough stretched by the extensigraph hook.*

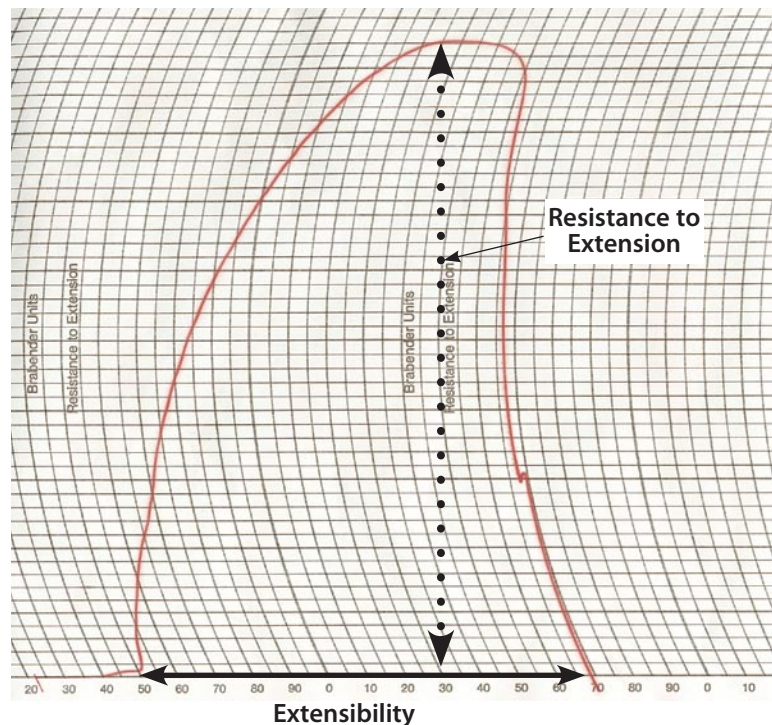
### Why is this important?

Results from the extensigraph test are useful in determining the gluten strength and bread-making characteristics of flour. The effect of fermentation time and additives on dough performance can also be evaluated.

- 
- **Visco-elastic recorder**
  - **Measures dough extensibility and resistance to extension**
-



## Weak Gluten Flour



## Strong Gluten Flour

The extensigraph test measures and records the resistance of a dough to stretching.

- **Resistance to Extension** is the R value and is indicated by the maximum height of the curve. It is expressed in centimeters (cc), Brabender units (BU), or Extensigraph units (EU).
- **Extensibility** is the E value and is indicated by the length of the curve. It is expressed in millimeters (mm) or centimeters (cm).
- **R/E Ratio** indicates the balance between dough strength (resistance to extension) and the extent to which the dough can be stretched before breaking (extensibility).
- **Area Under the Curve** is a combination of resistance and extensibility. It is expressed in square centimeters (cm<sup>2</sup>).

Weak gluten flour has a lower resistance to extension (R value) than strong gluten flour.

*Adapted from Method 54-10, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*

# Alveograph

## Method

1. A sample of 250 grams of flour is mixed with a salt solution to form a dough.
2. Five 4.5 centimeter circular dough patties are formed and then rested in the alveograph in a temperature-regulated compartment at 25 degrees Celsius for approximately 20 minutes.
3. Each dough patty is tested individually. The alveograph blows air into a dough patty, which expands into a bubble that eventually breaks.
4. The pressure inside the bubble is recorded as a curve on graph paper.

## Results

- The alveograph determines the gluten strength of a dough by measuring the force required to blow and break a bubble of dough.
- The results include P Value, L Value, and W Value.
- A stronger dough requires more force to blow and break the bubble (higher P value).
- A bigger bubble means the dough can stretch to a very thin membrane before breaking.
- A bigger bubble indicates the dough has higher extensibility; that is, its ability to stretch before breaking (L value).
- A bigger bubble requires more force and will have a greater area under the curve (W value).
- Alveograph curves are described on page 50.

## Why is this important?

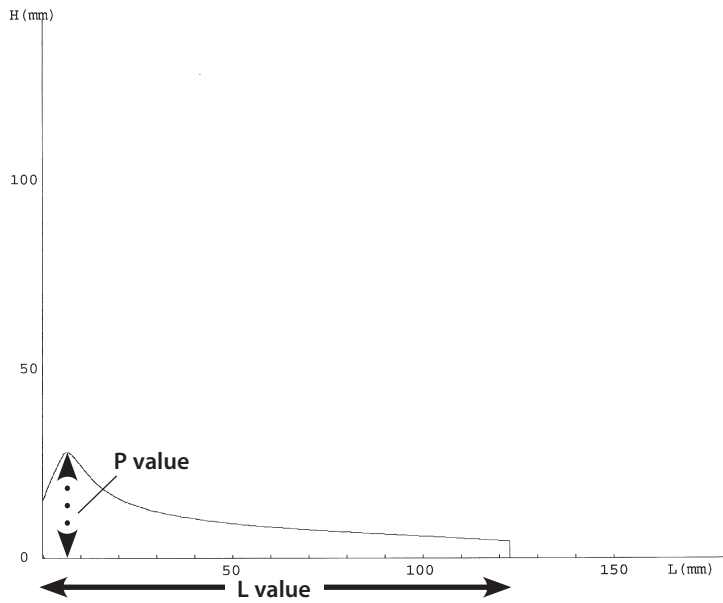
The alveograph test provides results that are common specifications used by flour millers and processors to ensure a more consistent process and product. The alveograph is well



*Alveograph machine.*

suited for measuring the dough characteristics of weak gluten wheats. Weak gluten flour with low P value (strength of gluten) and long L value (extensibility) is preferred for cakes and other confectionery products. Strong gluten flour will have high P values and is preferred for breads.

- 
- **Visco-elastic recorder**
  - **Measures dough strength**
-



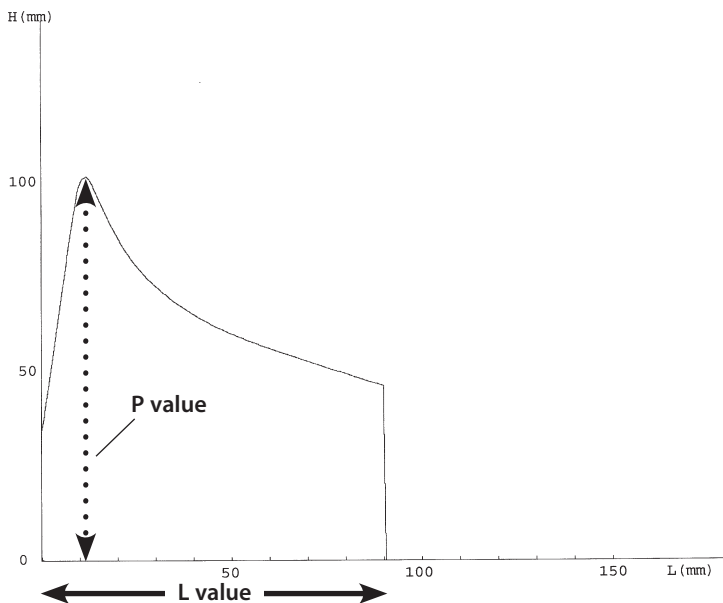
**Weak Gluten Flour**

The alveograph test measures and records the force required to blow and break a bubble of dough.

- **P Value** is the force required to blow the bubble of dough. It is indicated by the maximum height of the curve and is expressed in millimeters (mm).
- **L Value** is the extensibility of the dough before the bubble breaks. It is indicated by the length of the curve and is expressed in millimeters (mm).
- **P/L Ratio** is the balance between dough strength and extensibility.
- **W Value** is the area under the curve. It is a combination of dough strength (P value) and extensibility (L value) and is expressed in joules.

Weak gluten flour has lower P values than strong gluten flour.

*Adapted from Method 54-30A, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*



**Strong Gluten Flour**

## Mixograph

### Method

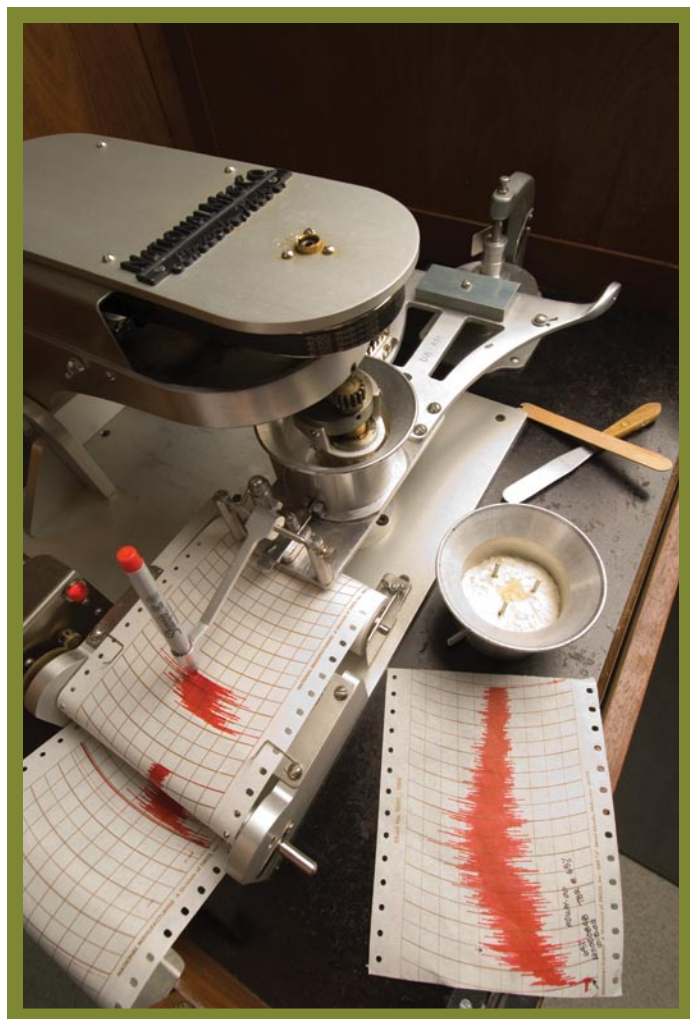
1. A sample of 35 grams of flour on a 14 percent moisture basis is weighed and placed in a mixograph bowl.
2. Water is added to the flour from a buret and the bowl is inserted into the mixograph.
3. The flour and water are mixed together to form a dough.
4. As the dough is mixed, the mixograph records a curve on graph paper.

### Results

- The mixograph determines dough and gluten properties of a flour by measuring the resistance of a dough against the mixing action of pins.
- Mixograph results include water absorption, peak time, and mixing tolerance.
- The mixograph curve indicates gluten strength, optimum dough development time, mixing tolerance (tolerance to over-mixing), and other dough characteristics.
- The amount of water added (absorption) affects the position of the curve on the graph paper. Less water increases dough consistency and moves the curve upward.
- Mixograph curves are described on pages 42 to 43.

### Why is this important?

The mixograph test quickly analyzes small quantities of flour for dough gluten strength. Wheat breeders use mixograph results to screen early generation lines for dough gluten strength. Flour water absorption measured by the mixograph often serves as bake absorption in bread baking tests.



*Mixograph mixer.*

- 
- **Recording dough mixer**
  - **Measures flour water absorption and dough mixing characteristics**
-

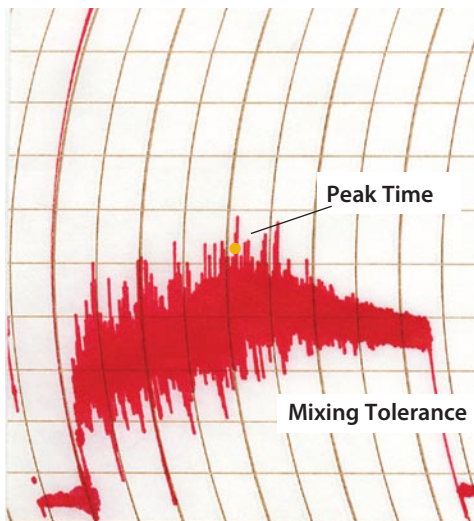
The Mixograph Test measures and records the resistance of a dough to mixing with pins.

- **Peak Time** is the dough development time, beginning the moment the mixer and the recorder are started and continuing until the dough reaches maximum consistency. This indicates optimum mixing time and is expressed in minutes.

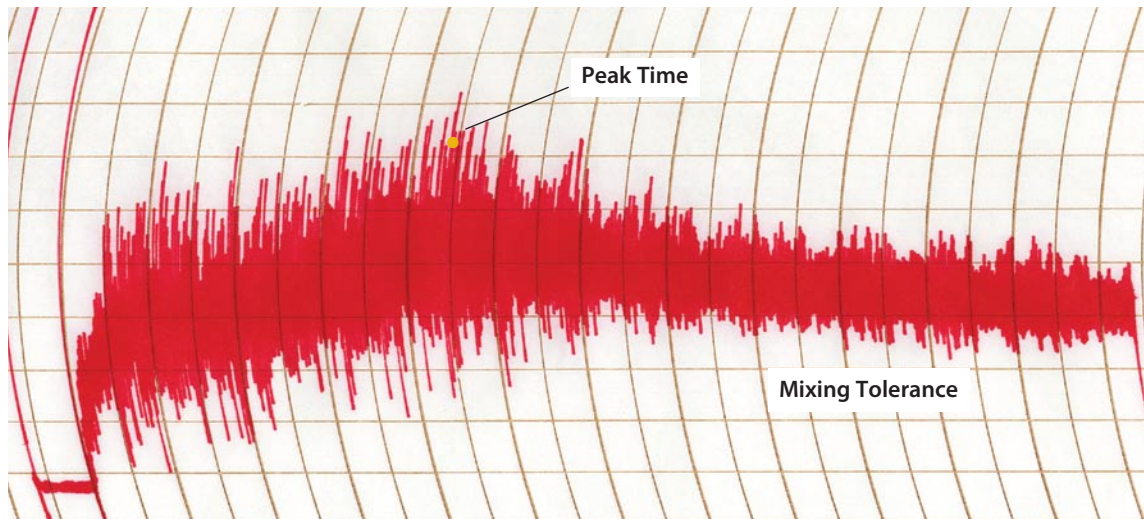
- **Mixing Tolerance** is the resistance of the dough to breakdown during continued mixing and affects the shape of the curve. This indicates tolerance to over-mixing and is expressed as a numerical score based on comparison to a control.

Weak gluten flour has a shorter peak time and less mixing tolerance than strong gluten flour.

*Adapted from Method 54-40A, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*



**Weak Gluten Flour**



**Strong Gluten Flour**

## Glutomatic

### Method

1. A 10-gram sample of flour or ground wheat is weighed and placed into the glutomatic washing chamber on top of the polyester screen.
2. The sample is mixed and washed with a 2 percent salt solution for 5 minutes.
3. The wet gluten is removed from the washing chamber, placed in the centrifuge holder, and centrifuged.
4. The residue retained on top of the screen and through the screen is weighed.

### Results

- Wet gluten content is determined by washing the flour or ground wheat sample with a salt solution to remove the starch and other solubles from the sample. The residue remaining after washing is the wet gluten.
- During centrifugation, the gluten is forced through a sieve. The percentage of gluten remaining on the sieve is defined as the Gluten Index, which is an indication of gluten strength. A high gluten index indicates strong gluten.
- Wet gluten content results are expressed as a percentage on a 14 percent moisture basis; for example, 35 percent for high protein, strong gluten wheat or 23 percent for low protein, weak gluten wheat.



*Glutomatic mixer.*

### Why is this important?

The wet gluten test provides information on the quantity and estimates the quality of gluten in wheat or flour samples. Gluten is responsible for the elasticity and extensibility characteristics of flour dough. Wet gluten reflects protein content and is a common flour specification required by end-users in the food industry.

*Adapted from Method 38-12A, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*

- 
- **Gluten washing**
  - **Measures wet gluten content**
-

# Amylograph

## Method

1. A sample of 65 grams of flour is combined with 450 milliliters of distilled water and mixed to make a slurry.
2. The slurry is stirred while being heated in the amylograph, beginning at 30 degrees Celsius and increasing at a constant rate of 1.5 degrees Celsius per minute until the slurry reaches 95 degrees Celsius.
3. The amylograph records the resistance to stirring as a viscosity curve on graph paper.

## Results

- The amylograph analyzes viscosity by measuring the resistance of a flour-and-water slurry to the stirring action of pins or paddles.
- When the slurry is heated, the starch granules swell and the slurry becomes a paste.
- A thicker slurry has more resistance to the pins during stirring and has a higher peak viscosity. Generally, a thicker slurry indicates less enzyme activity and makes better products.
- Amylograph results include peak viscosity.
- Amylograph curves are described on pages 46 to 47

## Why is this important?

The amylograph test measures flour starch properties and enzyme activity, which results from sprout damage (alpha amylase enzyme activity). Sprouting in wheat, as indicated by high enzyme activity, produces sticky dough that can cause problems during processing and results in products with poor color and weak texture. For Asian noodle products, flour of



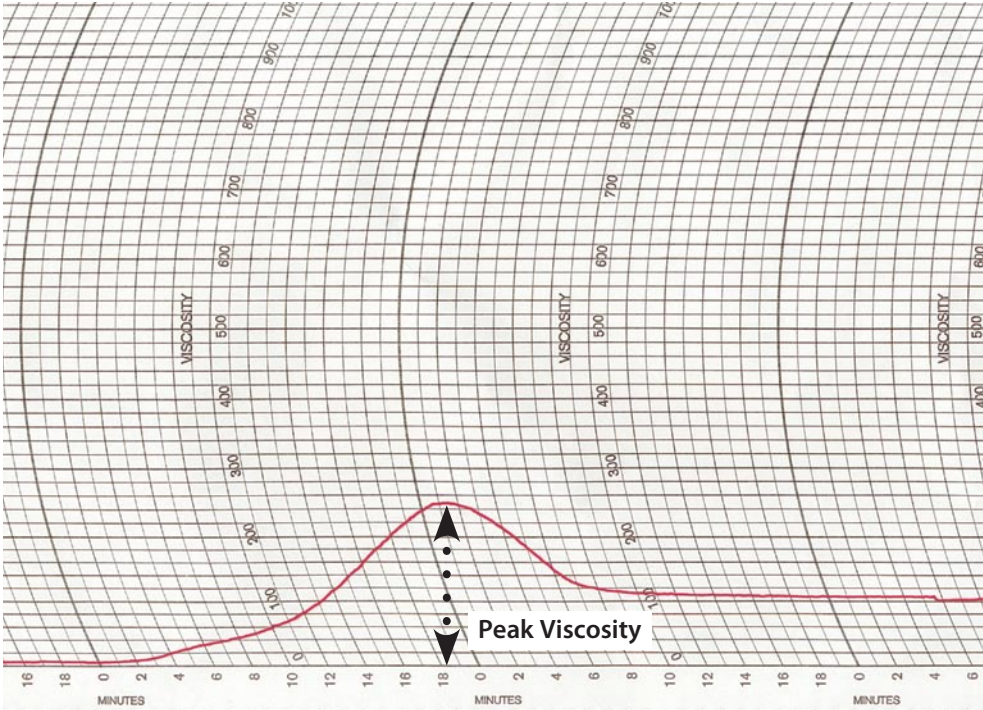
*Amylograph mixer.*

medium to high peak viscosity is preferred because it gives noodles better texture characteristics.

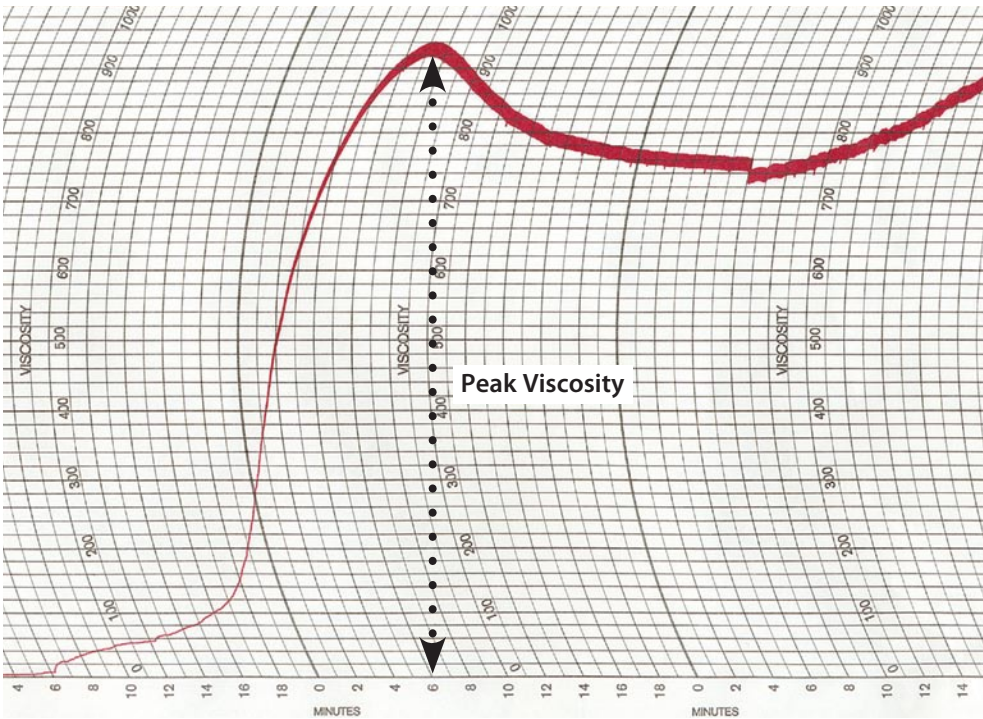
Both the amylograph and the rapid visco analyzer (RVA, pages 54 to 56) measure starch viscosity properties. The amylograph is more commonly used throughout the world. The RVA uses a smaller sample and takes less time than the amylograph.

- 
- **Viscosity analysis**
  - **Measures flour starch properties**
-





### Sprouted Wheat Flour



### Sound Wheat Flour

The amylograph test measures and records the resistance of a heated slurry (a flour and water paste) to the stirring action of pins.\*

- **Peak Viscosity** is the maximum resistance of a heated flour and water slurry to mixing with pins. It is expressed in Brabender units (BU).

Sprouted wheat flour has a lower peak viscosity than sound flour.

\* Some laboratories use paddles rather than pins.

Adapted from Method 22-12, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.

## Rapid Visco Analyzer

### Method

1. A sample of 3.5 grams of flour is mixed with 25 milliliters of water to form a slurry.
2. The rapid visco analyzer stirs the slurry as it is heated from 60 to 95 degrees Celsius in 6 minutes.
3. The maximum viscosity (peak viscosity) is recorded as a curve by the rapid visco analyzer.

### Results

- The rapid visco analyzer indicates starch viscosity by measuring the resistance of a flour and water slurry to the stirring action of a paddle.
- When the slurry is heated, the starch granules swell and make the slurry thicker.
- A thicker slurry has more resistance to the paddle during stirring and has a higher peak viscosity.
- The highest point during the heating cycle is the peak viscosity.
- Rapid visco analyzer results include peak viscosity and are expressed in rapid visco units (RVU).
- A viscosity curve is shown on the computer monitor in the photo on page 48.

### Why is this important?

The rapid visco analyzer test measures flour starch properties. For Asian noodle products, flour of medium to high peak viscosity is preferred because it gives noodles better texture characteristics.\*

The rapid visco analyzer can also be used to determine the stirring number, which is related to sprout damage. A stirring



*Rapid visco analyzer.*

number test is performed to measure enzyme activity that results from sprout damage (alpha amylase enzyme activity). Sprouting in wheat results in flour that produces sticky dough that can cause problems during processing. Sprout-damaged flour also produces products with poor color and weak texture.\*\*

*\*Adapted from RVA-4 Series Operation Manual, Newport Scientific Pty. Ltd. 1995.*

*\*\*Adapted from Method 22-08, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*

- 
- **Viscosity analysis**
  - **Measures flour starch properties**
-

## Solvent Retention Capacity (SRC)

### Method

1. Prepare four solvents: deionized water, 50 percent sucrose, 5 percent sodium carbonate, and 5 percent lactic acid.
2. Weigh 5 grams of flour in a 50 milliliter conical bottom polypropylene centrifuge tube for mixing with each solvent.
3. Add 25 grams of a solvent and cap tube.
4. Shake vigorously for 5 seconds to suspend flour.
5. Shake for 5 seconds at 5, 10, 15, and 20 minutes.
6. Centrifuge for 15 minutes without braking.
7. Invert tube and drain for 10 minutes.
8. Weigh tube with residue.
9. Repeat steps 2 through 8 for each solvent.

### Results

- Solvent retention capacity (SRC) is the weight of solvent held by flour after centrifuging
- SRC is expressed as percent of flour weight, on a 14 percent moisture basis.
- Four solvents are independently used to produce values for each solvent: water SRC, 50 percent sucrose SRC, 5 percent sodium carbonate SRC, and 5 percent lactic acid SRC.



### Why is this important?

Generally, lactic acid SRC is associated with gluten protein characteristics. Sodium carbonate SRC is related to levels of damaged starch and sucrose SRC with pentosan components. Water SRC is influenced by all water adsorbing components in flour. The combined pattern of these flour SRC results establishes a practical flour quality and functionality profile that is useful in predicting baking performance.

# Section 5: Product Tests

---

<i>Pan Bread</i> .....	59
<i>Flat Bread</i> .....	60
<i>Hearth Bread</i> .....	61
<i>Sugar Snap Cookie</i> .....	62
<i>Extruded Pasta</i> .....	63
<i>Asian Sheeted Noodles</i> .....	64
<i>Asian Noodle Color Analysis</i> .....	65
<i>Asian Noodle Texture Analysis</i> .....	66
<i>Sponge Cake</i> .....	67
<i>Asian Steamed Bread</i> .....	68

## Pan Bread

### Formula

Flour*	100 grams
Dry yeast	1 gram
Sugar	6.0 grams
Salt	1.5 grams
Shortening	3.0 grams
Water	Variable (58–70 grams)
Malted barley	0.2 grams

\*14% moisture basis

*Additional ingredients may include oxidants or dough conditioners. In baking formulas, ingredients are expressed as a percentage of flour weight.*

### Procedure

1. Flour and other ingredients are mixed with a yeast suspension to form a dough.
2. The dough is mixed until it reaches optimum dough development.
3. The dough is rounded and placed into a fermentation cabinet at 30 degrees Celsius and 85 percent relative humidity for 105 minutes.
4. First Punch – The dough is passed through a sheeter, folded twice, and returned to the fermentation cabinet for 50 minutes.
5. Second Punch – The dough is passed through a sheeter, folded twice, and returned to the fermentation cabinet for 25 minutes.
6. The dough is molded into a cylinder shape and proofed in a pan for 62 minutes.
7. The dough is baked in a 215 degrees Celsius oven for 24 minutes and then cooled to room temperature.



*White pan bread.*

### Results

- Pan bread is evaluated for processing characteristics, external and internal characteristics, and texture. The results are expressed as a numerical score based on comparison to a control sample.
- Pan bread dough is evaluated during processing for strength, extensibility, and stickiness.
- Pan bread is weighed and measured for volume. Results are expressed in grams for weight and in cubic centimeters (cc) for volume. Specific volume is the ratio of volume to weight.
- Pan bread is scored for exterior appearance, internal uniform crumb grain, and texture.

### Why is this important?

The pan bread test provides end-users with information on flour quality characteristics. Bakers need flours that perform consistently, especially in high-speed commercial operations. Consumers desire a consistent product that meets expectations for volume, color, and texture.

*Adapted from Method 10-10B, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*

## Flat Bread

### Egyptian Baladi Flat Bread

#### Formula

Flour*	100 grams
80-95 percent extraction	
Compressed yeast	1.5 grams
Salt	1.0 gram
Water	65–70 grams
<i>enough to make a sticky dough</i>	

\*14 percent moisture basis

#### Procedure

1. Flour is combined with a yeast suspension and a salt solution and mixed to optimum dough development.
2. The dough is placed in a fermentation cabinet at 28 degrees Celsius and 85 percent relative humidity for 40 to 50 minutes.
3. After removal from the fermentation cabinet, the dough is divided into equal pieces and formed into balls by hand.
4. The dough pieces are rested for 10 to 20 minutes and then dusted with flour and compressed by hand or in a sheeter.
5. The dough pieces are returned to the fermentation cabinet and proofed for 30 to 45 minutes.
6. The dough pieces are baked in a 450 to 500 degrees Celsius oven for 1 to 2 minutes.

#### Results

- Flat bread is evaluated for processing performance and consumer expectations. The results are expressed as a numerical score based on comparison to a control sample.
- Dough is evaluated for stickiness during processing, extensibility, and strength.



*Flat breads of various countries.*

- Flat bread is evaluated for texture, flexibility, shape, color, and shelf life.
- Flat bread is scored for appearance, uniform crumb grain, and texture.

#### Why is this important?

Flat bread is a diverse product, including a broad range of items such as tortillas in Mexico, chapati in India, and shaobin in China. Consumers desire a consistent product that meets expectations for color and texture. Bakers need flours that perform consistently, especially in high-speed commercial operations. The flat bread test provides information to manufacturers on processing performance of flour. The stickiness of a dough is a significant factor in flat bread production since flat bread baked in a tandoor oven must be sticky to adhere to the oven during baking. Flat bread baked in a conventional oven must not stick to the oven during baking.

*Protocol developed by Dr. Hamza A. Hamza, U.S. Wheat Associates, Cairo, Egypt.*

## Hearth Bread

### Baguette Pre-ferment Dough

#### Formula

Flour	120 grams
Water	80 grams
Salt	2.5 grams
Instant yeast	0.2 grams

1. Flour is combined with yeast and blended for 10 seconds.
2. Water and salt are added and mixed for 5 minutes to form a pre-ferment dough.
3. The pre-ferment dough is covered and rested for 3 to 12 hours at room temperature.

### Baguette Dough

#### Formula

Flour	1,000 grams
Pre-ferment dough	200 grams
Water	680 grams
Salt	22 grams
Instant yeast	10 grams

#### Procedure

1. Flour is combined with yeast and blended for 10 seconds. Water and salt are added and mixed to form a dough.
2. The pre-ferment dough is added slowly and mixed.
3. The dough is covered and rested for 20 minutes, then divided, shaped into cylinders, and rested again.
4. The cylinders are covered and proofed for 90 minutes.
5. A few evenly placed cuts are made on top of the shaped dough.
6. The shaped dough is baked for 25 minutes at 240 degrees Celsius top heat and 200 degrees Celsius bottom heat.



*Hearth bread and rolls.*

### Results

- Hearth bread is evaluated for processing characteristics, external and internal characteristics, appearance, and texture. The results are expressed as a numerical score based on comparison to a control sample.
- Dough properties are evaluated for strength and extensibility.
- Hearth bread is weighed and measured for volume. Results are expressed in grams for weight and in cubic centimeters for volume. Specific volume is the ratio of volume to weight.
- Hearth bread is scored for appearance, crumb structure, and texture.

### Why is this important?

The hearth bread test provides information that can be used to optimize processing conditions prior to commercial-scale baking. Final product attributes, such as appearance, flavor, and texture, can be evaluated on small dough batches with this test.

*Protocol developed by Roy Chung, U.S. Wheat Associates, Singapore.*

## Sugar Snap Cookie

### Formula

Flour*	40 grams
Sugar	24 grams
Shortening	12 grams
Nonfat dry milk	1.2 grams
Sodium bicarbonate	0.4 grams
Solution of sodium bicarbonate	0.32 grams
Solution of ammonium chloride and salt	0.2 grams 0.18 grams
Water	Variable (0.3 to 2.1 milliliters)

\*14 percent moisture basis

### Procedure

1. Sugar, nonfat dry milk, and sodium bicarbonate are sifted together, combined with the shortening, and creamed.
2. A sample of 37.6 grams of creamed mass is weighed out and combined with water, a solution of sodium bicarbonate, and a solution of ammonium chloride and salt.
3. Flour is added and mixed in to form a dough.
4. The dough is rolled out to a consistent thickness, cut into circles, and placed on a greased cookie sheet.
5. The cookies are baked at 205 degrees Celsius for 11 minutes.
6. The cookies are cooled on the cookie sheet for 5 minutes before removing to a cooling rack.



*Sugar snap cookies.*

### Results

- Sugar snap cookies are evaluated for cookie spread (diameter) and top grain appearance. The results are expressed as a numerical score based on comparison to a control sample.
- Cookie spread is measured and the results are expressed in centimeters.
- Top grain is evaluated by visual examination of the pattern of cracks and “islands” on the top surface of the cookie and a numerical score is given.

### Why is this important?

The sugar snap cookie test is used worldwide to evaluate the performance of wheat flour for use in a wide range of confectionery products. Flour with low protein and weak gluten, which produces cookies with a high cookie spread and numerous cracks on the surface, usually performs well for these products.

*Adapted from Method 10-52, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*



## Extruded Pasta

### Formula

Semolina*	100 grams
Water	31.5 grams

\*Note: Semolina is a coarse milled product made from durum wheat.

### Procedure

1. A sample of semolina is weighed and placed in a mixing bowl.
2. Semolina is mixed at low speed as water is added over a 30-second period and then mixed at high speed for 4 minutes to form a dough.
3. The dough is transferred to the extruder and extruded into pasta product.
4. The extruded pasta product is cut to length and dried.

### Results

- Extruded pasta is evaluated for processing performance, texture, color, external characteristics, and cooking qualities. The results are expressed as a numerical score based on comparison to a control sample.
- Processing performance is determined for dough strength and extensibility.
- External characteristics are determined for surface smoothness and appearance, including color, clarity, specks, and cracks.
- Cooked pasta is evaluated by sensory analysis for cooking qualities, such as firm bite (“al dente”), non-stickiness, flavor, and mouthfeel.
- Texture can be determined with an instrument test; for example, the TA.XT2 Texture Analyzer (similar to Asian noodle texture test; see page 66).



*Different pasta shapes.*

### Why is this important?

Processing conditions can be optimized with the extruded pasta test prior to commercial-scale operations. Final product attributes, such as stickiness, texture, and color, can be predicted on small-scale equipment.

Strength and extensibility of dry pasta is a key factor in pasta production since the product must be mechanically strong to maintain its size and shape during cutting, packaging, handling, and shipping.

Preferred characteristics of extruded pasta, such as color and texture, are determined by consumer desires and expectations.

*Adapted from Method 66-41, Approved Methods of the American Association of Cereal Chemists, 10th Edition. 2000. St. Paul, MN.*

# Asian Sheeted Noodles

## Formula

Flour*	1,000 grams
Salt	12 to 20 grams
Water	280 to 400 grams

\*14 percent moisture basis

*Additional ingredients that affect color or texture may be added:*

Eggs

Sodium hydroxide

Sodium or potassium carbonate (kansui)

Starches

Gums

## Procedure

1. Flour is combined with a salt-and-water solution and mixed for 12 minutes to form a crumbly dough.
2. The dough is rested for 30 minutes to thoroughly redistribute moisture.
3. The dough is compressed between two pairs of rollers with a 3 millimeter gap in a noodle machine.
4. Two dough sheets are combined and passed through rollers with a 4 or 5 millimeter gap.
5. The dough sheet is rested for 30 minutes to thoroughly redistribute moisture.
6. The dough sheet continues to be sheeted at progressively reduced gaps until desired thickness (1 to 2 millimeters) is achieved.
7. The dough sheet is slit to specified size and shaped for noodle type.

## Results

- Asian noodles are evaluated for processing performance, color, and texture. The results are expressed as a numerical score based on comparison to a control sample.
- Processing performance is determined by dough handling properties such as extensibility, ease of



*Inspecting extruded noodles.*

processing, dough smoothness, non-stickiness, and ease of slitting.

- Color is evaluated by visual examination for whiteness, yellowness, and brightness. Color can also be measured with the Minolta chroma meter test and expressed as L\*, a\*, and b\* values (see page 65).
- Cooked noodle texture is evaluated by sensory analysis to score for bite, chewiness, springiness, and mouthfeel. Texture can also be determined by the TA.XT2 texture analyzer test to provide texture parameters such as hardness, springiness, cohesiveness, and chewiness (see page 66).

## Why is this important?

Noodle makers need a balance of gluten strength and extensibility to keep the dough sheet from tearing during processing. Specifications for noodle color and texture vary by noodle type. Preferred characteristics are determined by consumer desires and expectations in each market. The Asian sheeted noodle test predicts properties that are important for commercial noodle processors.

*Protocol developed at Wheat Marketing Center, Inc., Portland, Oregon.*

## Asian Noodle Color Analysis

One method used to analyze product color in laboratory tests and commercial products, such as sheeted noodles and other products, is the Minolta chroma meter test. To determine Asian noodle color, the dough sheet is analyzed as follows.

### Procedure

1. A sample of 3 Asian noodle dough sheets are cut just prior to slitting and then stacked together.
2. Measurements are taken in two locations on both the top and bottom on 2 out of 3 dough sheets with the Minolta chroma meter, and an average  $L^*$ ,  $a^*$ , and  $b^*$  are recorded.
3. Two readings are taken at 0 and 24 hours on each side of two dough sheets, and an average  $L^*$ ,  $a^*$ , and  $b^*$  are recorded.

### Results

- Asian noodle color is determined by measuring the color components of a noodle sample with the Minolta chroma meter.
- Asian noodle color results are reported in terms of color values based on the following rating scale:

$L^*$ value	whiteness	100 white
		0 black
$a^*$ value	positive values	+60 red color
	negative values	-60 green color
$b^*$ value	positive values	+60 yellow color
	negative values	-60 blue color



*Noodles range in color from white to yellow based on type of noodles consumed in each market.*

- Typical Asian noodle color is described as bright white, creamy white, pale yellow, or intense yellow. For example, a good color Chinese raw noodle should have a minimum  $L^*$  value of 72.0 at 24 hours after production.

### Why is this important?

Noodle color is one of the most important Asian noodle product quality characteristics because it is the first attribute perceived by consumers. Asian noodle color may be white or yellow depending upon the noodle type, but it should be bright.

*Protocol developed at Wheat Marketing Center, Inc., Portland, Oregon.*

## Asian Noodle Texture Analysis

One method used to analyze texture in laboratory tests and commercial products, such as sheeted noodles, extruded pasta, and sponge cake, is the TA.XT2 texture analyzer test.

### Procedure

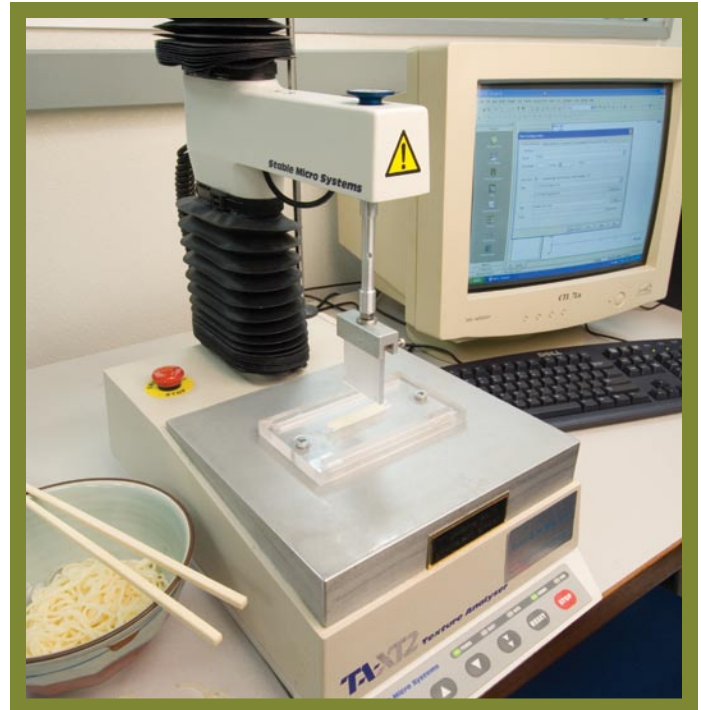
1. A 100-gram sample of noodles is cooked in 1 liter of boiling water for 3 to 5 minutes.
2. The noodles are rinsed with cool tap water and drained.

### Textural Measurement

1. A sample of 5 noodle strands are randomly selected and cut into ~7 centimeter pieces.
2. The 5 noodle pieces are laid side by side on the TA.XT2 Texture Analyzer instrument platform.
3. A 2-bite (compression) test is performed using a special plastic tooth. Compression is performed to 70 percent of noodle thickness.

### Results

- Asian noodle texture is determined as hardness, springiness, cohesiveness, and chewiness with the TA.XT2 texture analyzer.
- Hardness indicates noodle bite and is expressed as hard bite or soft bite.
- Springiness indicates the degree of recovery after the first bite.
- Cohesiveness is a measure of noodle structure.
- Chewiness is a single parameter that incorporates firmness, cohesiveness, and springiness.
- A typical Chinese raw noodle has the following measurements: springiness 0.96, hardness 1,200 grams, cohesiveness 0.66, and chewiness 750 grams.



*Texture measurement of cooked noodles is performed with a texture analyzer.*

### Why is this important?

Noodle texture is an important quality characteristic. Based on the noodle type and the marketplace, noodle texture can be hard bite or soft bite. For example, Udon noodles are usually softer and more elastic while other noodles are harder and chewier in bite.

*Protocol developed at Wheat Marketing Center, Inc., Portland, Oregon.*

## Sponge Cake

### Formula

Flour*	100 grams
Eggs	100 grams
Sugar	100 grams
Water	40 grams

\*14 percent moisture basis

### Procedure

1. Eggs, water, and sugar are mixed together with gentle heating to achieve a foamy batter with a consistent viscosity (target specific gravity:  $25 \pm 1$  grams per milliliter; temperature:  $30 \pm 1$  degrees Celsius).
2. Flour is folded into the batter and poured into a round cake pan with a paper liner.
3. The cake is baked at 180 degrees Celsius for 30 minutes.
4. The cake is removed from the oven and placed on a wire cake rack to cool.

### Results

- Sponge cake is evaluated for volume, external and internal characteristics, and texture. The results are expressed as a numerical score based on comparison to a control sample.
- Sponge cake is weighed and measured for volume. The results are expressed in grams for weight and in cubic centimeters for volume.
- External characteristics are evaluated by visual examination for shape, crust color, and cake appearance.



*Sponge cake.*

- Internal characteristics are evaluated by visual examination for cell uniformity, cell size, and cell wall thickness.
- Texture can be determined for softness with the TA.XT2 Texture Analyzer (see page 66).

### Why is this important?

Sponge cake is a popular dessert in Asia. Sponge cake production is a typical use of weak gluten flour, which is used for many confectionery products. The sponge cake test allows manufacturers to evaluate the suitability of the flour for these products. Flour with low protein content, low ash content, and weak gluten characteristics makes good quality sponge cake.

*Protocol developed by Dr. Seiichi Nagao at Nisshin Flour Milling Co., Ltd., Tokyo, Japan.*

# Asian Steamed Bread

## Formula

Flour*	400 grams
Dry yeast	4.0 grams
Water	180 to 208 grams

\*14 percent moisture basis

*Additional ingredients that affect texture and flavor may be added:*

Sugar

Shortening

Baking powder

Starches

## Procedure

1. Flour and other ingredients are combined with a yeast suspension and water and then mixed to form a dough.
2. The dough is covered and rested in a bowl for 10 minutes at room temperature.
3. The dough is folded into thirds and compressed in a sheeter 12 times, or until it is uniformly smooth, and then rolled into a cylinder and cut into pieces 30 grams each.
4. The dough pieces are proofed and then steamed in a steamer for 7 minutes. Last, they are cooled for 30 minutes.

## Results

- Asian steamed bread is evaluated for processing performance, volume, weight, internal and external characteristics, eating quality, and flavor. The results are expressed as a numerical score based on comparison to a control sample.
- Asian steamed bread is weighed and measured for volume. The results are expressed in grams for weight and in cubic centimeters (cc) for volume. Specific volume is the ratio of volume to weight.
- Processing performance is evaluated for mixing, sheeting, rolling, cutting, and proofing.



*Asian steamed bread in multiple shapes.*

- External characteristics are scored for appearance and color.
- Internal characteristics are evaluated for structure, uniform crumb grain, and color (whiteness and brightness).
- Eating quality is scored for chewiness, bite, and non-stickiness. Flavor is scored for natural wheat flavor.

## Why is this important?

Steamed bread is a major use of wheat throughout Asia. It is often eaten with a meal as a staple food or as a snack or dessert. The performance of flour in processing is important to steamed bread manufacturers because it has an impact on end-product quality. The Asian steamed bread test determines processing characteristics by evaluating the balance between gluten strength and dough extensibility during sheeting. Superior steamed bread has a smooth skin, a firm and chewy texture, and a white fine-grain interior that is desired by consumers.

*Protocols developed at Wheat Marketing Center, Portland, Oregon.*



1. This publication was produced with financial assistance provided under the United States Department of Agriculture Market Access Program as authorized under Section 203 of the Agricultural Trade Act of 1978 and amended.
2. Disclaimer: The information in this publication was developed by the Wheat Marketing Center, Inc.; Kansas State University, Department of Grain Science and Industry, International Grains Program; and the Northern Crops Institute with the support of the North American Export Grain Association. The accuracy of the information reported and interpreted is not guaranteed. All contents are subject to correction and revision. WMC, K-State, NCI, and NAEGA disclaim any responsibility whatsoever for the use of the information contained herein.
3. Notice: In accordance with Federal law and U.S. Department of Agriculture, NAEGA, K-State, NCI, and WMC do not discriminate on the basis of race, color, national origin, sex, age, religion, or disability.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned.

Contents of this publication may be freely reproduced for educational purposes. All other rights reserved. In each case credit Wheat Marketing Center, *Wheat and Flour Testing Methods: A Guide to Understanding Wheat and Flour Quality, Version 2*, Kansas State University, September 2008.

**Kansas State University Agricultural Experiment Station and Cooperative Extension Service**

K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, as amended. Kansas State University, County Extension Councils, Extension Districts, and United States Department of Agriculture Cooperating, Fred A. Cholick, Director.