United States Department of Agriculture
Grain Inspection, Packers and Stockyards Administration
Federal Grain Inspection Service

Directive

9180.38 5-26-09

FALLING NUMBER DETERMINATION FOR WHEAT

1. PURPOSE

This directive transmits procedures for determining and certifying falling number (FN) results for wheat only. The service is provided upon request under the authority of the Agricultural Marketing Act of 1946, as amended (AMA). Testing services are available at selected Grain Inspection Packers and Stockyards Administration (GIPSA), Federal Grain Inspection Service (FGIS) field offices, State agencies, and the Technical Services Division (TSD), Quality Systems and Services (QSS) in Kansas City, Missouri.

2. REPLACEMENT HIGHLIGHTS

This directive is revised to provide, upon request of the applicant, Falling Number (FN) test results on a United States Grain Standards Act (USGSA) inspection certificate. This certification procedure is applicable only to FN tests that are performed in conjunction with other testing services performed under USGSA. FN testing performed independent of USGSA services must be reported on a AMA inspection certificate.

This directive supersedes FGIS Program Directive 9180.38, Falling Number For Wheat dated 3-20-06, and incorporates FGIS Program Notice PN-08-04, Certifying Falling Number Test Results.

3. BACKGROUND

Shortly before sprouting can be seen, there is a dramatic increase in the alpha-amylase enzyme activity of wheat kernels. Millers and bakers are very concerned about the level of alpha-amylase activity in wheat flour because excessive amounts break down starches to the extent that the flour's baking properties are adversely affected.

The FN determination indirectly measures alpha-amylase activity in a manner that simulates some of the changes flour undergoes during baking. Specifically, the "Falling Number" is the number of seconds required to stir and allow the stirrer to fall a measured distance through a hot aqueous flour gel undergoing liquefaction.

A high FN indicates low alpha-amylase activity or a viscous, gelled flour/water slurry. A low FN indicates high alpha-amylase activity or a less viscous, thin flour/water slurry.

The FN test is especially sensitive to small differences between the boiling points of the water bath and sample slurry. The test procedures outlined in this directive includes specific precautions and a trouble-shooting section for ensuring that boiling points of the bath and the sample slurry are as nearly equal as possible.

For purposes of this directive, wheat prepared for the FN test by the prescribed grinding method is referred to as "flour." The American Association of Cereal Chemists (AACC) method for "wheat flour" (meaning milled wheat flour) differs slightly from the method described in this directive.

4. EQUIPMENT AND SUPPLIES

FN apparatuses are manually, semiautomatically, or automatically operated, depending on the model used. Some models perform one determination at a time; others perform two tests simultaneously. The FN apparatus can be obtained from: a) Perten Instruments 1/ North America, Inc., P.O. Box 7398, Reno, NV 89510-7398 or b) Perten Instruments AB, P.O. Box 5101, S-141 05 Huddinge Sweden.

In addition to the FN apparatus itself, the following equipment and supplies are required.

a. Glass Tubes and Stoppers. The glass viscometer tubes are designed specifically for use with the FN apparatus and are manufactured to close tolerances (inner diameter, 21.00 ± 0.02 mm, outer diameter, 23.8 ± 0.3 mm, length 220.0 ± 0.3 mm).

Viscometer tubes purchased from Perten Instruments have been shown to consistently meet these tolerances, therefore, only tubes purchased from Perten Instruments may be used. Field offices are no longer required to have the TSD verify the tolerances and may order directly from Perten for delivery to the field office. FGIS field office managers will ensure that agencies use only approved viscometer tubes.

b. Barometer. Barometers are used for checking the operating conditions of the FN bath. Use an aneroid barometer that is readable (with interpolation) to 0.5 mm Hg or 0.07 kPa pressure. Calibrate the barometer to agree with the "station pressure" of the nearest weather station. Observe the following precautions:

1/ The mention of firm names or trade products does not imply that they are endorsed by the U.S. Department of Agriculture over other firms or similar products not mentioned.

(1) Specifically ask for the "station pressure", or the "true barometric pressure." For weather forecasting, meteorologists apply a correction to barometer readings to make them appear as if they were all taken at sea level.

Such "sea-level-corrected" readings are given by the media in the local weather report, and they may also be given by the National Weather Service over the phone. Use only the "station pressure" or the "true barometric pressure" to calibrate the laboratory barometer.

(2) If the laboratory altitude differs significantly from that of the weather station, the laboratory barometric pressure will also differ from the station pressure.

Atmospheric pressure drops approximately 0.027 mm Hg per ft. (0.012 kPa per meter or 0.001 in. Hg per ft.) of rise in elevation. Thus, if the laboratory is at a lower elevation than the weather station, the correction will be positive and if the laboratory is at a higher elevation, the correction will be negative. Apply the appropriate correction to the station pressure given by the weather station before calibrating the laboratory barometer. The maximum allowable difference between the altitudes of laboratory and weather station is ± 1,000 feet.

Example: The pressure at the nearest weather station is 29.60 in. Hg (751.8 mm Hg or 100.2 kPa), the weather station is at 550 ft. (168 meters) elevation, and the laboratory is at 700 ft. (213 meters) elevation.

Correction = (Station Elev. - Lab. Elev.) x 0.001

Calculation:

Correction = (550 ft. - 700 ft.) x .001 in. Hg/ft.
= -150 x 0.001 = -0.15 in. Hg.

The correction is negative and is subtracted from the weather station pressure. The true barometric pressure in this example is 29.60 in. Hg - 0.15 in. Hg = 29.45 in. Hg (748 mm Hg or 99.73kPa) and is the reading used to calibrate the laboratory barometer.

(3) After each barometer adjustment, check the barometer again within 1 week, and after that, check the barometer once per month. If at any time the barometer deviates from the correct reading by more than ± 0.10 in. Hg (± 2.5 mm) or ± 0.34 kPa, adjust as needed, and check it again within 1 week. Avoid calibrating or changing the barometer on days when the barometric pressure or the temperature is changing rapidly. Record the station pressure and the laboratory barometer readings in a permanent record.

c. Viscometer-stirrer. (supplied with the FN apparatus).

d. Thermometer. For checking the water bath temperature, use a thermometer (mercury or electronic type) which is marked in 0.2°C, or smaller, divisions and is accurate to ±0.3°C.

e. Grinder. Falling Number Mill, Model 3100, with a 0.8 mm screen. Replace the screen every 1,000 samples and whenever it appears damaged.

f. Balance. A precision-class balance with a specified accuracy of ±0.02 grams or better.

g. Water Dispenser. Graduated cylinder, 25.0 ml capacity, or an automatic pipette that delivers 25.0 ml (± 0.3 ml). Once each week, check the accuracy of the cylinder or the automatic pipette by weighing (with the precision balance) the amount of distilled water dispensed. If the weight of the dispensed distilled water is outside the range of 25.0 ± 0.3 grams, replace or re-calibrate the dispenser.

Operator may use a precision balance scale to routinely weigh 25.0 ± 0.3 grams of distilled water into a beaker. To dispense the distilled water, pour it into the viscometer tube.

h. Distilled Water.

i. Test Tube Brush or Spolett Rapid Cleaner.

j. Powder Funnel.

5. BASIS OF DETERMINATION

The FN test is based on a 7-gram representative portion taken from 250 grams of flour which has been ground from the whole wheat sample. Sufficient wheat must be ground to yield 250 grams of flour. Remove dockage and stones from the sample before grinding. See section 6, b for more details.

FN results are reported on a 14 percent moisture basis unless the applicant specifies another moisture basis. The applicant may request to have the FN results reported on the "as is" moisture basis, the dry matter (0 percent moisture) basis, or any other specified moisture basis. Only one moisture basis is reported on any one certificate.

There are three certification options available for export lots:

(1) Composite sample representing the entire lot.

(2) Individual sublot samples.

(3) An average of sublots using the approved method (see section 7 for more details).

Applicants must request the certification option prior to loading.

Perform all FN determinations in duplicate and report, on the official certificate, the average of the duplicate test results.

6. PROCEDURE

a. The Water Bath Temperature Verification. The FN apparatus water bath requires distilled water or deionized water. The FN value is affected by the boiling temperature of the water bath, which is a function of water purity and the atmospheric pressure. Elevated locations may obtain higher FN values than those determined at sea level. Therefore, altitude corrections are applied at locations having elevations at or above 2,000 ft. (610 meters).

Periodically check the water bath level while running FN tests. The FN apparatus includes an overflow tube on the water bath. The water level should be at the overflow level when viscometer tubes are in place. If the water level is slightly below the overflow outlet after running the first set of tubes. Immediately after a FN test in which the water level was at the overflow outlet, mark the new water level on the water level indicator. Maintain the water height at the mark, so that when a set of FN tubes is inserted, the water will rise to the overflow outlet.

Before the initial test of each day and/or after adding distilled water to the bath, verify that the bath temperature is correct for the true barometric pressure measured in the laboratory (see attachment 4, table 4). If the bath temperature deviates from the predicted temperature (table 3) by more than ±0.4°C, correct the problem before proceeding. (Refer to the section on troubleshooting for help in diagnosis).

DO NOT ADD CHEMICALS TO ADJUST THE WATER BATH TEMPERATURE AS THIS WILL LEAD TO ERRONEOUS RESULTS.

b. Moisture Determination and Sample Preparation of Whole Wheat. Determine the moisture content of the whole grain using the GAC 2100 moisture meter (refer to the Grain Inspection Handbook, Book II, section 1.10, for more details).

If the whole grain moisture is above 15.9 percent, air dry the sample (on an open pan at room temperature) to a moisture content of 15.9 percent or less before grinding, unless results are reported on an "as is" basis. Air drying to 15.9 percent moisture is not required for "as is" certification. Air dry enough grain so that the weight after drying is at least 250 grams (see attachment 3). Table 3 gives the predicted moisture content of the flour for whole grain moistures up to 15.9 percent.

A small number of sprouted kernels can affect the FN result significantly. To minimize sampling error, grind 250 grams of wheat (after removing dockage and stones). Place the ground sample in a clean container and cover it securely. Roll the container several times, then stir the sample with a spatula to blend it further. Run the grinder for 1 minute after each sample to allow the grinder to cool and to purge residual sample from the chamber to avoid contaminating samples. Clean the collection vessel after each sample. Clean the grinder daily and whenever sample build-up is observed.

c. FN Determination. Perform all FN determinations in duplicate as follows:

(l) Weigh 7.00 grams (± 0.05 grams) of the blended ground sample into a clean, dry viscometer tube.

(2) Add 25.0 ml (± 0.3 ml) distilled water (temperature 22°C ± 2°C). (If preferred, the water may be dispensed before the flour.)

NOTE: As soon as possible, after dispensing the sample and water, proceed with steps (3), (4), and (5) below.

(3) Shaking of the Viscometer Tubes.

(a) Hand Shaking - Insert the rubber stopper into the tube. Holding the tube securely in upright position with the thumb over the stopper, shake the tube up and down 20 times. Make certain that all the sample is suspended by upending the tube. If mixing is incomplete, repeat steps 6.c.(1) through 6.c.(3), above, and use a more brisk shaking action.

(b) Shaking using the Shakematic 1095 - The apparatus must be placed on a stable, horizontal surface. Insert a Shakematic stopper into the viscometer tube. Open the doors on the Shakematic by pressing the [OPEN] button. The [START] button will blink green. Insert the bottom of the tube into the hollow of the holder, then push the upper part of the tube into the top of the holder. Repeat this for the second tube. Close the doors manually. The [START] button will become a steady green light. Press the [START] button. The shaking starts and the green [START] button will turn red. The Shakematic will stop after a few seconds and the doors will automatically open when the shaking is complete. Carefully remove the viscometer tubes by first pulling the upper part out of its holder.

(4) Remove the stopper from the tube. Scrape the slurry coating from the stopper into the tube, then use the viscometer-stirrer to scrape down the slurry from the upper part of the tube. Thorough scraping of the stopper and tube is important.

(5) Place the tube and the viscometer-stirrer into the water bath tube holder within 40 seconds after the start of mixing. Start the timer immediately.

(a) When using the automatic apparatus, the stirring and settling cycle will begin automatically.

(b) When using the semiautomatic apparatus, swing the stirring motor unit into place over the top of the tube. When the timer registers exactly 5 seconds, push the lever on the motor unit to begin the stirring cycle. When the timer registers exactly 60 seconds, stop the stirring cycle with the viscometer-stirrer in its uppermost position. Swing the tripwire into place. When the test is completed, the timer will stop and a buzzer will sound.

(c) When using the manually-operated apparatus, begin stirring the sample exactly 5 seconds after placing the tube into the bath. Stir at the rate of exactly two strokes per second. Down and up is counted as one stroke. After 110 strokes, 60 seconds will have elapsed. Stop stirring with the viscometer-stirrer up, then swing the tripwire into place. Note the position of the viscometer-stirrer closely; when it reaches the tripwire, stop the timer.

(6) At the conclusion of the test, record the time in seconds.

There is very little alpha-amylase activity in samples with a FN result above 400. Thus, when the FN results exceed 400, record the results on the certificate as "more than 400." If an applicant requested the actual FN results or the actual result is needed for sublot analysis, allow the test to continue until completion.

(7) Hold the test tube under running water and remove the stirrer. Clean the stirrer and test tube thoroughly, making certain that all gelled material is removed from inside the black, ebonite neck of the viscometer-stirrer.

(8) **If the FN apparatus holds two viscometer tubes, perform duplicate tests at the same time. If the FN apparatus holds one viscometer tube, repeat the test using a second 7-gram portion from the 250-gram sample.** Some variation between duplicate tests is expected. If duplicate results differ by more than ± 5 percent from the average of the two tests, test a new duplicate set of sample portions. If both results are greater than 400, do not check the repeatability.

Determine the allowable deviation by multiplying the average result by 0.05.

Example: If the test results are 350 and 370, calculate the allowable deviation and the acceptable range as follows:

Average FN readings = (350 + 370) ÷ 2 = 360
Allowable deviation = 360 x 0.05 = ± 18 from 360
Acceptable FN readings must fall between 378 and 342.

(9) Record the duplicate test results and their average.

d. Altitude Correction for Wheat Sample After Grinding in the FN Model 3100 Mill.

(1) If the laboratory altitude is lower than 2,000 ft. (610 meters), FN readings are reported without corrections.

(2) If the laboratory altitude is 2,000 ft. (610 meters) or higher, correct the FN reading as shown in table 1 (see attachment 1).

For example, if the laboratory altitude is 3,000 ft. (914 meters) and the average FN reading is 325, the corrected FN is 283 (from table 1). For intermediate elevations and FN readings not listed in table 1, interpolate the results.

e. Moisture Correction. Using the GAC2100 moisture meter result (see section 6, b), estimate the moisture content of the ground sample from attachment 3, table 3, unless certification is requested on "as is" basis.

Record only one moisture basis on any one certificate.

Determine the moisture-corrected FN for any specified moisture basis, other than "as is," using the following formula. For "as is" moisture basis, report FN reading without correction.

$$\text{FN (specified mb)} = \frac{\text{Average FN (step c above) x (100 - M)}}{\text{(100 - P)}}$$

Where M is a specified moisture basis and P is the predicted moisture of the flour from table 3 based on the GAC 2100 percent moisture.

Example: GAC 2100 percent moisture is 12.7, predicted moisture (P) from table 3 is 12.3, and average FN result is 355.5 (as is). The moisture-corrected FN is calculated as follows:

(1) For dry matter basis (0 percent moisture basis):

FN = (355.5 x (100 - 0) ÷ (100 - 12.3)
= (355.5 x 100) ÷ 87.7 = 405.4 = 405

(2) For applicant specified moisture basis (example 12.0 percent moisture basis):

FN = (355.5 x (100 - 12)) ÷ (100 - 12.3)
= (355.5 x 88) ÷ 87.7 = 356.7 = 357

(3) For 14.0 percent moisture basis:

$$FN = (355.5 \times (100 - 14) \div (100 - 12.3)$$
$$= (355.5 \times 86) \div 87.7 = 348.6 = 349$$

NOTE: The moisture-corrected FN result is rounded to the nearest whole number for certification.

7. AVERAGING SUBLOT RESULTS

A special formula is used to average the sublot results because FN values do not have additive properties. For example, with the formula, samples with FN values of 380 and 70 yield an average FN of 88. Low FN results have a pronounced affect in lowering the average FN result when combined with a sample having a high FN reading.

The FN result is calculated as follows:

STEP 1: Convert each sublot FN reading to its Liquefaction Number (LN) equivalent. Use attachment 2, table 2, or, for readings outside the range of table 2, use the following formula:

$$LN = 6{,}000 \div (FN - 50)$$

STEP 2: Average the sublot LN values.

STEP 3: Convert the average LN value to its FN equivalent. Use table 2 or, for readings not listed or outside the range of table 2, use the following formula:

$$FN = (6{,}000 \div \text{Average LN}) + 50$$

Example:

STEP 1: Record FN values, LN equivalents, and calculate total LN.

S/L NO	FN	LN	S/L NO	FN	LN
1	300	24.0	7	325	21.8
2	375	18.5	8	250	30.0
3	100	120.0	9	350	20.0
4	200	40.0	10	275	26.7
5	225	34.3	11	325	21.8
6	400	17.1	12	500	13.3

Total LN = 387.5

STEP 2: Average the LN values.

LN average = 387.5 ÷ 12 = 32.29
LN after rounding = 32.3

STEP 3: FN = (6,000 ÷ 32.3) + 50
= 185.76 + 50
= 235.76

FN average after rounding = 236

8. CERTIFICATION

a. AMA Certification:

Report FN results on the inspection certificate (lot or sample) in accordance with chapter 6 of the Processed Commodities Handbook.

On the inspection certificate, describe the commodity as "Wheat." Under "Results of Inspection," report the FN result with the applicable statement below. FN results are reported for certification to the nearest whole number.

(1) "Falling Number: ___ , ____ percent moisture basis."
(Use this statement to report FN results on any specified moisture basis.)

(2) "Falling Number:___, dry matter basis."

(3) "Falling Number:___, as is moisture basis."

Divided lot inspection certificates are available (for lot inspections only) upon request of the applicant.

b. Optional (USGSA) Certification:

At the request of the applicant for service GIPSA will provide FN results in the “Results” section of the USGSA inspection certificate.

When FN results are reported on a USGSA inspection certificate the following qualifying statement must be entered in the "Remarks" section of the certificate.

"Falling Number results provided under the authority of the Agricultural Marketing Act (AMA) of 1946."

This certification procedure is applicable only to FN tests that are performed in conjunction with other testing services performed under the USGSA. FN testing performed independent of USGSA services must be reported on an AMA inspection certificate.

9. RETEST AND APPEAL

A retest and/or appeal inspection is available upon request by the applicant. A retest is performed on the basis of the whole grain file sample, and an appeal is performed on the basis of the whole grain file sample or a new sample (AMA Part 868.33 and 868.35).

a. A retest inspection may be performed by the same office that performed the original inspection.

b. Appeal inspections may be performed by GIPSA's Technical Services Division, FGIS field office, or Federal/State office that monitored the office that performed the original inspection or retest, when requested by the applicant.

Official personnel shall not perform a retest or appeal inspection if they participated in a previous inspection unless there is only one authorized person available at the time and place of the requested service. Also, whenever possible, the retest or appeal inspection should be performed on a different FN apparatus than the one used for the original inspection.

The applicant may also request a retest and appeal inspection of individual sublots without separate certification. That is, a single inspection certificate for a shiplot may use original, retest, and appeal results for different sublots for the final certification.

The retest or appeal inspection shall be performed according to the procedures specified in this directive for original FN determinations.

10. QUALITY CONTROL

GIPSA's, Technical Services Division (TSD) is responsible for the quality control of official FN tests performed at all service points. To accomplish this, TSD will prepare check samples for service points every 6 months (biannually). The check sample set will include a minimum of three wheat samples having FN levels ranging from approximately

200 to 350. One or more of the samples will be whole grain; the remainder will be meal or flour. Check sample sets will include instructions for completing the biannual check.

TSD will establish tolerances and action limits based on historical data and will provide statistical analysis and plots of results to field locations.

TSD may distribute additional check samples periodically and may request monitoring samples from selected locations.

11. TROUBLE-SHOOTING

The following list of symptoms and possible causes is given as a help for diagnosing and correcting errors in the FN test. The list is not all-inclusive, but serves as an aid in conducting the local quality control program.

a. Discrepancy in Bath Temperature and Barometric Pressure. Possible causes and solutions:

(1) Bath not yet up to temperature. The Model 1800 may switch to the ready mode before a full boil is reached. Wait for a rolling boil before reading the temperature.

(2) Heater malfunction. Interruption of heating may be caused by a burnt-out fuse or heater element. The Model 1800 does not give a "bath cold" error message until the temperature has fallen to about 90°C.

(3) Thermometer too close to heater coil. Local superheating near the heater coil may raise the thermometer reading by as much as 2º. The thermometer should be perpendicular and immersed in water up to the immersion line.

(4) Impure bath water. Impurities may change the boiling temperature of the bath water. Use only distilled or deionized water in the bath. Do not add chemicals to the bath water. Routinely replace the bath water at least once a week.

(5) Barometer inaccuracy. Verify the barometer calibration as described in section 4.b.

(6) Thermometer inaccuracy. A precision thermometer becomes inaccurate when a separation or a gas bubble exists in the mercury column. Follow the manufacturer's instructions for removing separations/bubbles.

(7) Thermometer calibration error. Thermometer accuracy can be altered by exposure to extreme temperatures, e.g., heating it in a flame to remove column mercury separations, or by exposure to high temperature for long periods of time. If you doubt the reading of the thermometer, check it against a second thermometer that is known to be correct within $\pm$ 0.2°C by comparing the readings of the two in the boiling water bath.

b. Sources of Error in the FN Test. Possible causes and solutions.

(1) Error in measuring bath temperature and/or barometric pressure. The daily temperature-pressure check serves as a test for hidden errors. For a typical sample with FN of 300, a forced increase of 0.2°C will decrease the FN test result by about 20 seconds. If the measured temperature differs from predicted temperature (table 3) by more than $\pm$ 0.4°C, refer to section 11. a., above.

(2) Incomplete mixing of samples. Samples for FN analysis must be mixed until uniform throughout. (See section 6. b.).

(3) Balance error. For a typical sample with FN of 300, an increase of 0.05 grams will increase the FN test result by about 5 seconds. Check the balance using standard weights totaling 7.00 grams. A balance error exceeding $\pm$ 0.02 grams indicates that balance service or repair is required.

(4) Water dispenser error. For a typical sample with FN of 300, an increase of 1 ml will decrease the FN test result by about 5 seconds. Check the dispenser accuracy as described in section 4. g. Liquid dispensers, although convenient, have hidden sources of error. For example, raising the plunger too rapidly may cause a short burst of liquid to eject from the tip when the adjustable stop is contacted. Furthermore, expelling the syringe too rapidly often causes liquid to briefly continue flowing from the tip after the syringe is emptied. Fill and empty the dispenser only at rates which accurately and reproducibly dispense the 25.0 ml of water.

(5) Incorrect temperature of sample water. For a typical sample with FN of 300, an increase in sample water temperature of 1°C will decrease the FN test result by about 2 seconds. Determine the temperature of the sample water. If needed, place the dispenser reservoir in a cool or warm bath to bring it to 20-24°C.

(6) Impure sample dilution water. The use of tap water, rather than distilled/deionized water, for mixing with the ground sample usually has a small, but measurable, effect on the FN result. Use only distilled or deionized water as the sample water.

(7) Failure to scrape. Failure to scrape the slurry residue from the stopper into the tube and from the tube walls down into the slurry will decrease the FN test result.

(8) Improper timing. Exceeding the 40-second time limit for scraping the stopper, scraping the tube walls, inserting the tubes, and starting the timer.

(9) Improper mixing. Failure to hold the tube vertically while mixing the slurry may affect the test result.

(10) Incomplete mixing. Check for incomplete mixing by momentarily inverting the tube. If lumps or pockets of thick slurry are seen, a more brisk mixing action is needed. Repeat the test rather than continuing shaking.

(11) Incorrect bath level. Check the bath level between analyses to verify it has not fallen below the mark (section 6. a.). Adjust the bath level by adding distilled water to the bath, then wait until a full boil is restored before checking temperature and running the next test.

(12) Error in moisture correction. An error of 1 percent in the moisture reading will cause an error of approximately 1 percent in the FN result, after correction to 14 percent moisture basis.

(13) Erosion of grinder screen. Stones in FN samples can quickly erode or damage the grinder screen, thus permitting particles larger than 0.8 mm to exit the grinding chamber. A coarse grind will decrease the FN test result. If in doubt about the condition of the screen replace it with a new 0.8 mm screen.

(14) Incorrect stirrer weight. The manufacturer's specification for the stirrer weight-plunger assembly (without plastic collar) is 25.00 ± 0.05 g.

(15) Out-of-tolerance viscosity tubes. For tube specifications, refer to section 4. a.

(16) Operator differences. Non-agreement between operators has often been traced to different mixing actions and/or timing of procedural steps.

c. Consistent small difference between sides of the Model 1800.

(1) Differences in treatment of duplicate tests. The timing of each step in the test procedure, especially mixing, scraping, inserting the tubes, and starting the timer, should be as nearly identical as possible. Also, the mixing action applied to each tube should be as identical as possible.

(2) Asymmetry of heater shape has been reported to cause different results between the left and right sides. The orientation of the heater element is adjustable, within limits, by turning the bath vessel on its base.

One field location reported that the left and right sides were brought into agreement by this method. Matching index marks were then made on the edges of the vessel and lid. Test results of the two sides were kept in agreement by aligning the two marks each time the bath was assembled.

(3) Hot spot on heater element can also cause these small differences.

/s/ John C. Giler

John C. Giler, Director
Field Management Division

Attachments

TABLE 1
ALTITUDE-CORRECTED FN VALUES FOR WHEAT AT
DIFFERENT LABORATORY ALTITUDES (FT. ABOVE SEA LEVEL)

FALLING NUMBER	ALTITUDE (FT. ABOVE SEA LEVEL)						
TEST RESULTS	2000	2500	3000	3500	4000	4500	5000
100	84	81	80	78	77	77	77
105	88	86	84	82	81	81	80
110	93	90	88	86	85	85	84
115	97	95	92	91	89	89	88
120	102	99	97	95	94	93	92
125	107	104	101	99	98	97	96
130	111	108	105	103	102	101	100
135	116	113	110	108	106	105	104
140	120	117	114	112	110	109	108
145	125	122	119	116	114	113	112
150	130	126	123	121	118	117	116
155	134	131	127	125	123	121	120
160	139	135	132	129	127	125	124
165	144	140	136	133	131	129	128
170	148	144	141	138	135	133	132
175	153	149	145	142	140	137	135
180	158	153	150	146	144	141	139
185	162	158	154	151	148	145	143
190	167	163	159	155	152	150	147
195	172	167	163	160	156	154	151
200	176	172	168	164	161	158	155
205	181	176	172	168	165	162	159
210	186	181	177	173	169	166	163
215	191	186	181	177	173	170	167
220	195	190	186	182	178	174	171
225	200	195	190	186	182	178	175
230	205	200	195	190	186	183	179
235	210	204	199	195	191	187	183
240	214	209	204	199	195	191	187
245	219	214	209	204	199	195	191
250	224	218	213	208	204	199	195
255	229	223	218	213	208	203	199
260	234	228	222	217	212	207	203
265	239	233	227	222	216	212	207
270	243	237	232	226	221	216	211

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DIFFERENT LABORATORY ALTITUDES (FT. ABOVE SEA LEVEL)

FALLING NUMBER	ALTITUDE (FT. ABOVE SEA LEVEL)						
TEST RESULTS	2000	2500	3000	3500	4000	4500	5000
275	248	242	236	231	225	220	215
280	253	247	241	235	229	224	219
285	258	252	245	240	234	228	223
290	263	256	250	244	238	232	227
295	268	261	255	249	243	237	231
300	272	266	259	253	247	241	235
305	277	271	264	258	251	245	239
310	282	275	269	262	256	249	243
315	287	280	273	267	260	253	1247
320	292	285	278	271	264	258	251
325	297	290	283	276	269	262	255
330	302	295	287	280	273	266	259
335	307	299	292	285	277	270	263
340	312	304	297	289	282	274	267
345	317	309	302	294	286	279	271
350	321	314	306	298	291	283	275
355	326	319	311	303	295	287	279
360	331	324	316	308	299	291	283
365	336	328	320	312	304	295	287
370	341	333	325	317	308	300	291
375	346	338	330	321	313	304	295
380	351	342	335	326	317	308	299
385	356	348	339	331	322	312	303
390	361	353	344	335	326	316	307
395	366	358	349	340	330	321	311
400	371	363	354	344	335	325	315
405	376	367	358	349	339	329	319
410	381	372	363	354	344	333	323
415	386	377	368	358	348	338	327
420	391	382	373	363	353	342	331
425	396	387	377	367	357	346	335
430	401	392	382	372	361	350	339
435	406	397	387	377	366	355	343
440	411	402	392	381	370	359	347
445	416	407	397	386	375	363	351

TABLE 1
ALTITUDE-CORRECTED FN VALUES FOR WHEAT AT
DIFFERENT LABORATORY ALTITUDES (FT. ABOVE SEA LEVEL)

FALLING NUMBER	ALTITUDE (FT. ABOVE SEA LEVEL)						
TEST RESULTS	2000	2500	3000	3500	4000	4500	5000
450	421	411	401	391	379	367	355
455	426	416	406	395	384	372	359
460	431	421	411	400	388	376	363
465	436	426	416	405	393	380	367
470	441	431	421	409	397	384	371
475	446	436	425	414	402	389	375
480	451	441	430	419	406	393	379
485	456	446	435	423	411	397	383
490	461	451	440	428	415	401	387
495	466	456	445	433	420	406	391
500	471	461	450	437	424	410	395

TABLE 2
TABLE FOR CONVERTING BETWEEN
FALLING NUMBER (FN) AND LIQUEFACTION NUMBER (LN) VALUES

FN	LN	FN	LN	FN	LN	FN	LN
70.0	300.0	100.0	120.0	130.0	75.0	160.0	54.5
71.0	285.7	101.0	117.6	131.0	74.1	161.0	54.1
72.0	272.7	102.0	115.4	132.0	73.2	162.0	53.6
73.0	260.9	103.0	113.2	133.0	72.3	163.0	53.1
74.0	250.0	104.0	111.1	134.0	71.4	164.0	52.6
75.0	240.0	105.0	109.1	135.0	70.6	165.0	52.2
76.0	230.8	106.0	107.1	136.0	69.8	166.0	51.7
77.0	222.2	107.0	105.3	137.0	69.0	167.0	51.3
78.0	214.3	108.0	103.4	138.0	68.2	168.0	50.8
79.0	206.9	109.0	101.7	139.0	67.4	169.0	50.4
80.0	200.0	110.0	100.0	140.0	66.7	170.0	50.0
81.0	193.5	111.0	98.4	141.0	65.9	171.0	49.6
82.0	187.5	112.0	96.8	142.0	65.2	172.0	49.2
83.0	181.8	113.0	95.2	143.0	64.5	173.0	48.8
84.0	176.5	114.0	93.8	144.0	63.8	174.0	48.4
85.0	171.4	115.0	92.3	145.0	63.2	175.0	48.0
86.0	166.7	116.0	90.9	146.0	62.5	176.0	47.6
87.0	162.2	117.0	89.6	147.0	61.9	177.0	47.2
88.0	157.9	118.0	88.2	148.0	61.2	178.0	46.9
89.0	153.8	119.0	87.0	149.0	60.6	179.0	46.5
90.0	150.0	120.0	85.7	150.0	60.0	180.0	46.2
91.0	146.3	121.0	84.5	151.0	59.4	181.0	45.8
92.0	142.9	122.0	83.3	152.0	58.8	182.0	45.5
93.0	139.5	123.0	82.2	153.0	58.3	183.0	45.1
94.0	136.4	124.0	81.1	154.0	57.7	184.0	44.8
95.0	133.3	125.0	80.0	155.0	57.1	185.0	44.4
96.0	130.4	126.0	78.9	156.0	56.6	186.0	44.1
97.0	127.7	127.0	77.9	157.0	56.1	187.0	43.8
98.0	125.0	128.0	76.9	158.0	55.5	188.0	43.5
99.0	122.4	129.0	75.9	159.0	55.0	189.0	43.2

When converting LN to FN:

1. If the LN corresponds to two (2) FN values, use the **EVEN** FN value. **Example**: LN 23.3 converts to FN value of 308.
2. If the LN corresponds to three (3) FN values, use the **MIDDLE** FN value. **Example**: LN 16.9 converts to FN value of 405.
3. If the LN is 13.5, **USE** the FN value of 495.
4. If the LN is not listed, use the nearest LN on the table or use the formula “FN = (6000÷ LN) + 50" to calculate the FN equivalent.

TABLE 2
TABLE FOR CONVERTING BETWEEN
FALLING NUMBER (FN) AND LIQUEFACTION NUMBER (LN) VALUES

FN	LN	FN	LN	FN	LN	FN	LN
190.0	42.9	220.0	35.3	250.0	30.0	280.0	26.1
191.0	42.6	221.0	35.1	251.0	29.9	281.0	26.0
192.0	42.3	222.0	34.9	252.0	29.7	282.0	25.9
193.0	42.0	223.0	34.7	253.0	29.6	283.0	25.8
194.0	41.7	224.0	34.5	254.0	29.4	284.0	25.6
195.0	41.4	225.0	34.3	255.0	29.3	285.0	25.5
196.0	41.1	226.0	34.1	256.0	29.1	286.0	25.4
197.0	40.8	227.0	33.9	257.0	29.0	287.0	25.3
198.0	40.5	228.0	33.7	258.0	28.8	288.0	25.2
199.0	40.3	229.0	33.5	259.0	28.7	289.0	25.1
200.0	40.0	230.0	33.3	260.0	28.6	290.0	25.0
201.0	39.7	231.0	33.1	261.0	28.4	291.0	24.9
202.0	39.5	232.0	33.0	262.0	28.3	292.0	24.8
203.0	39.2	233.0	32.8	263.0	28.2	293.0	24.7
204.0	39.0	234.0	32.6	264.0	28.0	294.0	24.6
205.0	38.7	235.0	32.4	265.0	27.9	295.0	24.5
206.0	38.5	236.0	32.3	266.0	27.8	296.0	24.4
207.0	38.2	237.0	32.1	267.0	27.6	297.0	24.3
208.0	38.0	238.0	31.9	268.0	27.5	298.0	24.2
209.0	37.7	239.0	31.7	269.0	27.4	299.0	24.1
210.0	37.5	240.0	31.6	270.0	27.3	300.0	24.0
211.0	37.3	241.0	31.4	271.0	27.1	301.0	23.9
212.0	37.0	242.0	31.3	272.0	27.0	302.0	23.8
213.0	36.8	243.0	31.1	273.0	26.9	303.0	23.7
214.0	36.6	244.0	30.9	274.0	26.8	304.0	23.6
215.0	36.4	245.0	30.8	275.0	26.7	305.0	23.5
216.0	36.1	246.0	30.6	276.0	26.5	306.0	23.4
217.0	35.9	247.0	30.5	277.0	26.4	307.0	23.3
218.0	35.7	248.0	30.3	278.0	26.3	308.0	23.3
219.0	35.5	249.0	30.2	279.0	26.2	309.0	23.2

When converting LN to FN:

1. If the LN corresponds to two (2) FN values, use the **EVEN** FN value. **Example**: LN 23.3 converts to FN value of 308.
2. If the LN corresponds to three (3) FN values, use the **MIDDLE** FN value. **Example**: LN 16.9 converts to FN value of 405.
3. If the LN is 13.5, **USE** the FN value of 495.
4. If the LN is not listed, use the nearest LN on the table or use the formula “FN = (6000÷ LN) + 50" to calculate the FN equivalent.

TABLE 2
TABLE FOR CONVERTING BETWEEN
FALLING NUMBER (FN) AND LIQUEFACTION NUMBER (LN) VALUES

FN	LN	FN	LN	FN	LN	FN	LN
310.0	23.1	340.0	20.7	370.0	18.8	400.0	17.1
311.0	23.0	341.0	20.6	371.0	18.7	401.0	17.1
312.0	22.9	342.0	20.5	372.0	18.6	402.0	17.0
313.0	22.8	343.0	20.5	373.0	18.6	403.0	17.0
314.0	22.7	344.0	20.4	374.0	18.5	404.0	16.9
315.0	22.6	345.0	20.3	375.0	18.5	405.0	16.9
316.0	22.6	346.0	20.3	376.0	18.4	406.0	16.9
317.0	22.5	347.0	20.2	377.0	18.3	407.0	16.8
318.0	22.4	348.0	20.1	378.0	18.3	408.0	16.8
319.0	22.3	349.0	20.1	379.0	18.2	409.0	16.7
320.0	22.2	350.0	20.0	380.0	18.2	410.0	16.7
321.0	22.1	351.0	19.9	381.0	18.1	411.0	16.6
322.0	22.1	352.0	19.9	382.0	18.1	412.0	16.6
323.0	22.0	353.0	19.8	383.0	18.0	413.0	16.5
324.0	21.9	354.0	19.7	384.0	18.0	414.0	16.5
325.0	21.8	355.0	19.7	385.0	17.9	415.0	16.4
326.0	21.7	356.0	19.6	386.0	17.9	416.0	16.4
327.0	21.7	357.0	19.5	387.0	17.8	417.0	16.3
328.0	21.6	358.0	19.5	388.0	17.8	418.0	16.3
329.0	21.5	359.0	19.4	389.0	17.7	419.0	16.3
330.0	21.4	360.0	19.4	390.0	17.6	420.0	16.2
331.0	21.4	361.0	19.3	391.0	17.6	421.0	16.2
332.0	21.3	362.0	19.2	392.0	17.5	422.0	16.1
333.0	21.2	363.0	19.2	393.0	17.5	423.0	16.1
334.0	21.1	364.0	19.1	394.0	17.4	424.0	16.0
335.0	21.1	365.0	19.0	395.0	17.4	425.0	16.0
336.0	21.0	366.0	19.0	396.0	17.3	426.0	16.0
337.0	20.9	367.0	18.9	397.0	17.3	427.0	15.9
338.0	20.8	368.0	18.9	398.0	17.2	428.0	15.9
339.0	20.8	369.0	18.8	399.0	17.2	429.0	15.8

When converting LN to FN:

1. If the LN corresponds to two (2) FN values, use the **EVEN** FN value. **Example**: LN 23.3 converts to FN value of 308.
2. If the LN corresponds to three (3) FN values, use the **MIDDLE** FN value. **Example**: LN 16.9 converts to FN value of 405.
3. If the LN is 13.5, **USE** the FN value of 495.
4. If the LN is not listed, use the nearest LN on the table or use the formula “FN = (6000÷ LN) + 50" to calculate the FN equivalent.

TABLE 2
TABLE FOR CONVERTING BETWEEN
FALLING NUMBER (FN) AND LIQUEFACTION NUMBER (LN) VALUES

FN	LN	FN	LN	FN	LN	FN	LN
430.0	15.8	448.0	15.1	466.0	14.4	484.0	13.8
431.0	15.7	449.0	15.0	467.0	14.4	485.0	13.8
432.0	15.7	450.0	15.0	468.0	14.4	486.0	13.8
433.0	15.7	451.0	15.0	469.0	14.3	487.0	13.7
434.0	15.6	452.0	14.9	470.0	14.3	488.0	13.7
435.0	15.6	453.0	14.9	471.0	14.3	489.0	13.7
436.0	15.5	454.0	14.9	472.0	14.2	490.0	13.6
437.0	15.5	455.0	14.8	473.0	14.2	491.0	13.6
438.0	15.5	456.0	14.8	474.0	14.2	492.0	13.6
439.0	15.4	457.0	14.7	475.0	14.1	493.0	13.5
440.0	15.4	458.0	14.7	476.0	14.1	494.0	13.5
441.0	15.3	459.0	14.7	477.0	14.1	495.0	13.5
442.0	15.3	460.0	14.6	478.0	14.0	496.0	13.5
443.0	15.3	461.0	14.6	479.0	14.0	497.0	13.4
444.0	15.2	462.0	14.6	480.0	14.0	498.0	13.4
445.0	15.2	463.0	14.5	481.0	13.9	499.0	13.4
446.0	15.2	464.0	14.5	482.0	13.9	500.0	13.3
447.0	15.1	465.0	14.5	483.0	13.9	501.0	13.3

When converting LN to FN:

1. If the LN corresponds to two (2) FN values, use the **EVEN** FN value. **Example**: LN 23.3 converts to FN value of 308.
2. If the LN corresponds to three (3) FN values, use the **MIDDLE** FN value. **Example**: LN 16.9 converts to FN value of 405.
3. If the LN is 13.5, **USE** the FN value of 495.
4. If the LN is not listed, use the nearest LN on the table or use the formula "FN = (6000÷ LN) + 50" to calculate the FN equivalent.

TABLE 3

CONVERSION TABLE FOR PREDICTING PERCENT MOISTURE OF WHEAT SAMPLES GROUND IN THE FN MILL (MODEL 3100)

Predicted Moisture = 1.904606 + (0.81661 x M)

Where M = GAC 2100 Moisture

GAC 2100 Moisture %	Predicted Moisture for FN	GAC 2100 Moisture %	Predicted Moisture for FN
≤ 8.0	8.4	12.0	11.7
8.1	8.5	12.1	11.8
8.2	8.6	12.2	11.9
8.3	8.7	12.3	11.9
8.4	8.8	12.4	12.0
8.5	8.8	12.5	12.1
8.6	8.9	12.6	12.2
8.7	9.0	12.7	12.3
8.8	9.1	12.8	12.4
8.9	9.2	12.9	12.4
9.0	9.3	13.0	12.5
9.1	9.3	13.1	12.6
9.2	9.4	13.2	12.7
9.3	9.5	13.3	12.8
9.4	9.6	13.4	12.8
9.5	9.7	13.5	12.9
9.6	9.7	13.6	13.0
9.7	9.8	13.7	13.1
9.8	9.9	13.8	13.2
9.9	10.0	13.9	13.3
10.0	10.1	14.0	13.3
10.1	10.2	14.1	13.4
10.2	10.2	14.2	13.5
10.3	10.3	14.3	13.6
10.4	10.4	14.4	13.7
10.5	10.5	14.5	13.7
10.6	10.6	14.6	13.8
10.7	10.6	14.7	13.9
10.8	10.7	14.8	14.0
10.9	10.8	14.9	14.1
11.0	10.9	15.0	14.2
11.1	11.0	15.1	14.2
11.2	11.1	15.2	14.3
11.3	11.1	15.3	14.4
11.4	11.2	15.4	14.5
11.5	11.3	15.5	14.6
11.6	11.4	15.6	14.6
11.7	11.5	15.7	14.7
11.8	11.5	15.8	14.8
11.9	11.6	15.9	14.9

TABLE 4
BOILING POINT OF DISTILLED WATER (DEGREES C)
REFERENCED TO BAROMETRIC PRESSURE

Source: CRC Handbook of Chemistry and Physics, 50th Ed.
(Boiling Point Values were Corrected for the Effect
of Water Vapor-Saturated Headspace)

Barometric Pressure			Boiling Point (C)
(mm Hg)	(in. Hg)	kPa	
680	26.77	90.66	97.3
685	26.97	91.33	97.5
690	27.17	91.99	97.7
695	27.36	92.66	97.9
700	27.56	93.33	98.1
705	27.76	93.99	98.3
710	27.95	94.66	98.5
715	28.15	95.33	98.7
720	28.35	95.99	98.9
725	28.54	96.66	99.1
730	28.74	97.33	99.3
735	28.94	97.99	99.5
740	29.13	98.66	99.7
745	29.33	99.32	99.8
750	29.53	99.99	100.0
755	29.72	100.66	100.2
760	29.92	101.32	100.4
765	30.12	101.99	100.6
770	30.31	102.66	100.8
775	30.51	103.32	100.9
780	30.71	103.99	101.1
785	30.91	104.66	101.3
790	31.10	105.32	101.5
795	31.30	105.99	101.7
800	31.50	106.66	101.8

kPa = Kilopascal
mm = Millimeter
in = Inch
C = Centigrade