# *Moisture Analyzers*

# *MS-70 / MX-50*
# *MF-50 / ML-50*

## *Q&A / Users' Handbook*




Version 2.30M

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*International Div., A&D Company, Limited*

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# ■ Basics

## A. Measurement

### 1. Moisture content

**What is moisture content?**

Moisture content is usually expressed as the percentage of water mass in a solid, liquid or gas.
When the sample is a gas or partially liquid, it can also be expressed as a percentage of water mass versus sample volume. Furthermore, for gases, moisture content can also be referred to as hygroscopic moisture or humidity.
Since moisture content can be classified in various ways and with various names depending on the state of the sample, the evaluation and handling of measurement data requires special care.
Moisture mechanically adhered to a material's (sample's) surface can be called adhesive moisture, free water or hygroscopic moisture. Furthermore, under certain conditions (such as pressure, temperature, volume, etc.), moisture absorbed by a material can be called absorbed water or equilibrium moisture content. Finally, water chemically bonded to a material at the molecular level is referred to as water of crystallization or hydrated water, while this moisture is referred to as bonding moisture or combined water.

**Note**
Sodium tartrate dihydrate has theoretically known moisture and is a typical standard sample for the measurement of moisture content using a moisture analyzer. It is a by-product of the production and preservation of alcohols such as wine and has been used by people for ages.
Using the classifications above, this material is a hydrate with water of crystallization. Sodium tartrate (molecular formula: $Na_2C_4H_4O_6$, rational formula $[\text{-CH(OH)COONa}]_2$; molecular mass: 194.0517) and two water molecules ($2H_2O$, molecular mass 36.03056) combine chemically to form sodium tartrate dihydrate (molecular formula: $Na_2C_4H_4O_6 \cdot 2H_2O$, rational formula $[H_2O.CH(OH)COONa]_2$ / molecular mass 230.0823).
Heating sodium tartrate dihydrate releases the two water molecules and changes the material to sodium tartrate (anhydrate).
Sodium tartrate dihydrate's melting point is 150℃. At room temperature, it is stable and does not release the water of crystallization in its molecules. When the temperature rises to 200℃, intermolecular bonds other than water of crystallization start break. Accordingly, when using sodium tartrate dihydrate as a test sample for a measurement with a heated-air moisture analyzer, the heating temperature should be greater than 150℃ but less than 200℃ to ensure that only water of crystallization is evaporated.
Therefore, the moisture percentage (moisture content) of sodium tartrate dihydrate can be theoretically obtained from the ratio of the molecular weight of the two intermolecular water molecules and the sodium tartrate dihydrate, as shown in the formula below.

$$(36.03056/230.0823) \times 100 \fallingdotseq 15.66\%$$

### 2. Method of measurement

**How a moisture analyzer measures moisture content**

Moisture content can be measured by various methods, including drying, the Karl Fischer method, the dielectric method, the infrared absorption method, a neutron analyzer and the crystal oscillation method. Of these methods, heating and drying and the Karl Fischer method are most frequently used in laboratories, while the infrared absorption method and dielectric method are mainly used in processing.

In the heating method, the sample is heated for a period of time at or over the sample's transpiration temperature to dry the sample to evaporate its water. The moisture content is acquired as the reduction in

sample mass after heated-air drying. Weight loss gradually increases as a sample gets heated and finally reaches a constant value. Depending on its characteristics, samples may thermally decompose and vaporize if the heating temperature gets too high. This suggests that the loss in mass may not be completely water. However, optimal sample sizes, along with optimal heating conditions such as temperature and heating time, can lead results that are comparable to those obtained by methods such as the Karl Fischer method.
Compared to other methods, heating has clear and simple measurement principles and procedures. Furthermore, it requires minimal amount of equipment, which can be purchased, run, and maintained at a low cost. Due to these factors, it is suitable for a wide range of users and applications (samples). Its measurement range is from 0.01% or 0.1% to 100%, so even samples with almost 100% moisture content can be correctly and easily measured.
Heating method moisture analyzers use halogen lamps, infrared lamps, sheathed heaters, or microwave heaters to heat a sample. An electric balance weighs the sample before and after the heating to determine the moisture loss. The electric balance requires an insulated load sensor and an advanced design that eliminates effects such as temperature drift, since temperature can reach between 150 and 200 ºC.

In the Karl Fischer method, a Karl Fischer (KF) reagent, which includes iodine, hydrogen disulfide, and pyridine, responds specifically with water in the presence of methyl alcohol. Using this reaction, the moisture content of the sample is measured using volumetric and quantitative determination.

$$\underline{H_2O} + \underline{I_2+SO_2+3RN}+\underline{CH_3OH} \rightarrow 2RN.HI+RN.HSO_4CH_3\ (\text{anhydrate})$$

Water (reagent) KF reagent Methyl alcohol (RN: base, I: iodine, $SO_2$: hydrogen disulfide)

The measurement principles of the Karl Fischer method are based on the chemical reaction listed above. In other words, the KF reagent is added to the water in the sample to produce a selective chemical reaction and form an anhydrate. The end point of the reaction with water is detected electrically (by current) and the water moisture content of the sample is determined by the quantity of KF reagent required to reach the end point. Karl Fischer method is further divided into two methods, the coulometric and volumetric titration.
The Karl Fischer method requires a chemical reagent, which gradually deteriorates as natural internal reactions, as well as mixing and reaction with moisture in the air during storage and usage, cause its water equivalent to gradually decrease over time. Therefore, it is very important to confirm the water equivalent before measurement and carefully store the reagent. Due to these requirements, the Karl Fischer method is more complicated and requires more expensive equipment than heating methods, and therefore is more appropriate for detecting moisture content in gases or when the material has a moisture content of only a few ppm.

Moisture analyzers using infrared absorption utilize that fact that moisture absorbs specific wavelengths of infrared light. To eliminate variance due to irregularity or distance, the material surface is hit with three wavelengths, one that is absorbed by water and two others that are not. Moisture content is obtained from the energy ratio of the reflected light. This method can stably measure powder and grains in succession.

The ability to slow down neutrons varies by material. Neutron analyzers detect moisture in samples utilizing the widely varying ability to slow hydrogen. Fast neutron rays are slowed by the water in the sample and become thermal neutrons. The number of thermal neutrons then determines moisture content. Moisture content can be measured indirectly, non-destructively and consecutively on a line. Typical samples include sintered materials.

Some moisture analyzers have crystal oscillators with electrodes that have a thin, moisture-sensitive film. The moisture absorbed by the film changes the frequency of the crystal oscillator and analyzers use this change to detect the moisture content of the sample. This method is used to accurately measure trace quantities of moisture (at the ppm level) in gas samples.

| No. | Question | Answer |
|---|---|---|
| 1 | What is the difference between the MS/MX/MF/ML and a Karl Fischer type analyzer? | 1. The MS/MX/MF/ML is a heating and drying method analyzer that compares weight before and after heating and drying. Karl Fischer analyzers are electrochemical, with a KF reagent containing iodine being added at a fixed quantity.<br>2. Karl Fischer method can measure from a few ppm to 100% water but operation is complicated and units are expensive. The MS/MX/MF/ML is very easy to handle, measures quickly and is reasonably priced.<br>3. When the required resolution is under 0.01%, the MS/MX/MF/ML is more suitable in terms of handling, accuracy and running cost. There is no difference with data obtained with the Karl Fischer method and the MS/MX/MF/ML is likely to have better repeatability. |

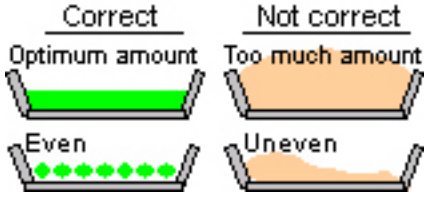
## 3. Accuracy (repeatability)

| No. | Question | Answer |
|---|---|---|
| 1 | What does a measurement accuracy of 0.02% mean? | This value represents the variation and repeatability of moisture content rate data when the same sample is tested repeatedly under the same conditions. In statistics, this value is referred to as standard deviation. |

## 4. Samples



| No. | Question | Answer |
|---|---|---|
| 1 | What is the reagent sodium tartrate dihydrate and when is it needed? | Sodium tartrate dihydrate ($Na_2C_4H_4O_6 \cdot 2H_2O$; molecular mass: 230.082) is sodium tartrate ($Na_2C_4H_4O_6$) chemically bonded to two water molecules ($2H_2O$; molecular mass: 36.031). The water separates from the sodium tartrate when heated. The moisture content rate of sodium tartrate dihydrate is the ratio of the molecular mass of the two water molecules, or 15.66% (36.031/230.082). Since its moisture content is theoretically known, it can be used as a test sample to confirm the performance of analyzers. Samples are included with the MS/MX/MF and are available as an option for the ML (12 pieces of 30 g). |
| 2 | Why don't I get a result of 15.66% when I measure sodium tartrate dihydrate? | 1. Moisture bonded inside of the material as crystal water is theoretically 15.66%. However, ambient air during usage and storage has moisture with a relative humidity of 10% to 90%, and moisture equivalent to 0.09% of the sample mass can adhere to the sample. Furthermore, moisture and impurities that have adhered to the pan, along with measurement instrument errors, can cause results to vary between 15.0 and 16.0% in actual measurements.<br>2. If there is a large difference between the actual result and 15.66, the heating temperature may be too low.<br>When using sodium tartrate dihydrate to test the accuracy of the MS/MX/MF/ML, set accuracy to MID and the heating temperature to 160 ºC and then pre-heat for 8 minutes. Next, spread approximately 5 g of the sample evenly on the pan and then measure at 160 ºC. |
| 3 | Is sodium tartrate dihydrate safe?<br>Is there any special handling process? | 1. Sodium tartrate dihydrate can be handled safely. It is used as a flavoring in foods and is harmless at normal dosages. (Acute toxicity: 218 g/50 kg (Median oral lethal dose for rats.)) However, contact with skin or the mucous membranes of the eyes and nose may cause a reaction. In such cases, wash the affected area immediately.<br>2. It can be disposed of as standard burnable waste. No special disposal process is required. |
| 4 | Can sodium tartrate dihydrate be reused? | No, it can be used for one test only. Once the moisture is released from the crystals from heating, it generally cannot be rehydrated. |

| No. | Question | Answer |
|---|---|---|
| 5 | Are there any items that the analyzer cannot test? | Do not test the following materials.<br>1. Explosive material, flammable material, and material that becomes hazardous when heated.<br>2. Material that forms a surface membrane when heated because the outer surface dries first. This may raise the internal pressure and cause the material to rupture.<br>3. Unknown material and material with unknown characteristics. |
| 6 | What is minimum sample weight? | The MS/MX/MF/ML can measure samples from 0.1g. When the sample amount is sufficient, the LCD displays a sample mark. |
| 7 | What is maximum sample weight? | The MS and MX/MF/ML can measure samples up to 71 g and 51 g, respectively.<br>The LCD displays an “E” if a sample is heavier these values. |
| 8 | Is it true that the larger the sample, the more accurate the measurement will be? | No. A larger sample may not get heated evenly on the inside or the heating time may become longer. In such cases, it may not be possible to achieve high accuracy (repeatability). |
| 9 | Can the analyzer measure low moisture samples (1% or less)? | The moisture mass of a sample with a moisture rate of 1% or less may be too low to accurately calculate the moisture content.<br>The following chart lists the required sample weights for estimated moisture contents.<br><br>**Estimated moisture content** / **Required sample weight**<br>0.1% / 20 g or more<br>0.5% / 5 g or more<br>1% / 2 g or more |
| 10 | Does placement of powder samples affect measurement results? | Yes, it affects moisture content results and repeatability. Accurate measurement requires even heating and vaporization, and poor sample distribution can negatively affect the distribution of heat to the sample.<br>Always place samples on the pan evenly. (See diagram.) Overheating and uneven distribution cause uneven heating and prevent complete drying.<br> |

## B. Calibration

| No. | Question | Answer |
|---|---|---|
| 1 | Is sodium tartrate dihydrate used for moisture content calibration of the MS/MX/MF/ML? | No, it is not used for calibration. However, it can be used to check performance (accuracy) since moisture content rate of the sample is theoretically known.<br>Since analyzers determine moisture content by weighing samples before and after heating, they are calibrated using a counterweight. Temperature can also be calibrated. |
| 2 | Can users calibrate the weight and temperature? | Yes. (Temperature calibration is possible with the MS-70 and MX-50 only). The calibration results can be printed out in accordance with GLP, GMP or ISO.<br>1. For weight calibration, use the optional AX-MX-41, a calibration mass of 20 g.<br>2. For temperature calibration, use the optional AX-MX-43, a certified temperature calibrator (for the MS-70 and MX-50 only.) |
| 3 | Are traceability system diagrams and certificates of measurement available? | Yes, both are available upon request.<br>1. Documentation for analyzers covers both weight and temperature.<br>2. Documentation for temperature calibrators (AX-MX-43) covers temperature only. Traceability and measurement certificates are included with calibrators at shipping free of charge. |

## C. Other Questions

| No. | Question | Answer |
|---|---|---|
| 1 | Should I be concerned about the moisture in a glass fiber sheet when it is used? | Not usually. However, if you want to be very strict, dry the sheet in the analyzer and store it in a desiccator prior to use. |
| 2 | Is the absolute measurement of the moisture content rate possible? (Can only water content be measured?) | No. While minerals such as metal, glass or sand have only water as moisture content, most samples, including organic matter, have materials other than water that can vaporize under certain temperature conditions. Also, samples that thermally decompose easily may show different measurement results depending on the heating temperature. |

## ■Introduction to Moisture Analyzers (MS-70/MX-50/MF-50/ML-50)

### A. Heating method

| *No.* | *Question* | *Answer* |
|---|---|---|
| 1 | What are the benefits of the halogen lamp in the MS/MX/MF/ML? | Halogen lamps have a higher heating value per unit of time than other heating methods, which can shorten measurement time. A halogen lamp emits much more light than other lamps, which is also beneficial when observing the sample during heating. They also have a longer lifetime. |
| 2 | What is difference between halogen and infrared lamps? How do they compare? | Ninety-five percent or more of the light emitted by a halogen lamp is within infrared wavelength field. Its optical characteristics are basically the same as an infrared lamp. |
| 3 | How fast can the halogen lamp heat? | It can heat a pan from the room temperature to 200 ºC in 2 minutes, which is much faster than an infrared or sheathed heater. |
| 4 | What is an SRA filter? | SRA stands for Secondary Radiation Assist and is an innovative heating method developed by A&D for the MS/MX/MF/ML moisture analyzer.<br>When a typical halogen lamp setup heats a sample on the pan, the sample is not heated evenly because some parts of the sample are closer to the lamp. With SRA, uniform secondary radiated heat from glass located directly under the lamp heats the sample evenly. (Patent approved) |

| No. | Question | Answer |
|---|---|---|
| 1 | What is the benefit of being able to see the inside of the analyzer during heating? | Being able to see inside the analyzer allows the user to comprehend the measurement conditions and provides assurance. Samples that may be scorched or burned from excess heating can partially vaporize from decomposition or combustion instead of evaporation, which invalidates the results. Therefore, it is very important for users to observe the sample through progress window to ensure the results are accurate.<br>Because the sample can be directly observed during heating, this feature is particularly useful when determining the optimal heating conditions for new samples. |
| 2 | What is the minimum measurement time? | It depends on material and moisture content. However, the 400 W halogen lamp of the MS/MX/MF/ML can heat pans from room temperature to 200 ºC in only 2 minutes.<br>Also, the SHS$^{TM}$ sensor on analytical balances measures very precisely, so smaller samples can be measured. With an appropriate heating temperature and sample mass, measurement can typically be completed within a few minutes to 20 minutes.<br>Thanks to the faster heating rate and smaller required sample size, the MS/MX/MF/ML heating and measurement times are shorter compared to conventional infrared heating. |
| 3 | Does the analyzer display the true sample temperature? | The temperature displayed by the analyzer during heating is the temperature of the pan. In other words, when the sample is spread evenly, it is the sample temperature. However, when the sample is placed unevenly or has hard surface membrane, the displayed temperature is the surface temperature of the sample.<br>MS/MX/MF/ML does not have the sensor placed directly over the pan. During design of the analyzer, two sensors, one above the pan and one embedded in the analyzer, measured temperature. A program uses the correlation of these sensors to accurately calibrate and display the correct temperature. Users of the MS/MX can calibrate the temperature using the optional calibrator to compare the display and actual temperature. |

| *No.* | *Question* | *Answer* |
|---|---|---|
| 4 | Why may the MS/MX/MF/ML have a lower moisture content rate and longer measurement time than the FD-620 with the same sample? | 1. The FD-620 displays a measurement temperature lower than the actual temperature above the sample. Therefore, the MS/MX/MF/ML heats to a higher temperature and tends to have longer measurement times and lower content values than the FD-620.<br>2. The MS/MX/MF/ML improves on the FD-620 and was designed so the actual temperature above the pan matches the setting and display temperatures. If you want to get the same result as the FD-620, reducing the sample mass by 1g and setting the end point condition to HI should produce a similar result. |
| 5 | What is highly accurate SHS? | SHS stands for Super Hybrid Sensor. A&D created this weight sensor to enable weighing within 1 second on average and significantly improve accuracy and long-term stability. This sensor is used in scales that require high resolution and accuracy.<br>The SHS enables the MS/MX/MF/ML moisture analyzer to capture dynamic weight changes during heating. Furthermore, the high resolution and accuracy allow for smaller sample sizes. These benefits enable the moisture content to be measured in shorter length of time. (Patent approved) |
| 6 | Why are two pan handles included? | If a pan is used for consecutive measurements and a sample is placed on a still-hot pan, water may evaporate before the start of measurement and make the measurement data inaccurate.<br>To avoid this, alternate two pans and handles. (The ML has one handle only because it has a lower resolution of 0.1%.)<br>Alternating enhances the reliability and repeatability of results. Furthermore, it improves operability during repeated measurements and prevents mishaps like burns. |

## ■ Application of the analyzer

### A. Measurement samples

### 1. Measurement methods

| No. | Question | Answer |
|---|---|---|
| 1 | Can soybeans and coffee beans be tested without processing? | No. Samples like beans should first be crushed in blender or mill because their surface and internal temperatures can be very different. Crushing decreases sample size and increases surface area and this results in more even heating and evaporation.<br>Note: Crushed samples must be measured quickly because the increased surface area absorbs the moisture from the air. |
| 2 | Can materials like milk or colloids be tested? | Colloids and liquids with solid particles floating on water such as milk often have dotted surfaces due to surface tension, which inhibits internal drying and prevents high-speed drying. In such cases, absorb the liquid sample with an optional accessory glass fiber sheet. This improves repeatability and shortens measurement time by one third to a half. Place the glass fiber sheet on the sample tray, zero the scale and then apply the sample.<br>* AX-MX-32-1 (For liquid samples with high surface tension. Sold separately. 70 mm dia., 100 sheets)<br>* AX-MX-32-2 (Same as sheets included with the MS/MX/MF. 78 mm dia., 100 sheets) |
| 3 | How should I measure items such as vegetables, seaweeds and mushrooms? | All samples must be representative of item as a whole. For items that have parts with different moisture rates like as vegetables and seafood, select or mix parts appropriate for evaluating the overall water content, while considering the sample mass.<br>Viscoelastic materials such as kelp and mushrooms should be ripped or cut up into smaller sizes and then measured. In such cases, quickly measure the sample to reduce the effects of moisture exchange with the environment. Furthermore, keep the heating temperature reasonably low to prevent combustion of the sample. |

## 2. Measurement report

This section compares the measurement results of the MX-50 and a Karl Fischer type analyzer with a plastic sample, which has a comparatively low moisture.

1) Measurement conditions
+ Sample: Plastic (PET)
+ Heating temperature: 180 ºC
+ Number of measurements: 5
+ Analyzers: MX-50 heating and drying method moisture analyzer (A&D)
Karl Fischer method moisture analyzer (KF)

2) Results

| Analyzer | Sample weight (g) | Moisture (%) | Repeatability (%) | Coefficient of variation (CV) (%) | Heating time (min) |
|---|---|---|---|---|---|
| MX-50 | 10 | 0.298 | 0.0045 | 1.49 | 6.8 |
| KF | 0.3 | 0.3072 | 0.0065 | 2.13 | 19 |

**Values for moisture and heating time are averages of 5 measurements. The number of digits is in line with the displayed values of each device. (Weight is excluded.)*

(1) The results showed no significant difference between the two analyzers, indicating that the MX-50 obtained the same results as a Karl Fischer type analyzer.
(2) Furthermore, the MX-50 had a lower coefficient of variance and better repeatability when the same sample was tested repeatedly.
(3) The MX-50 measured faster. The MX-50 took 6.8 minutes while the KF took 19 minutes, almost 3 times longer. Although not shown in the table above, the KF requires 6 minutes of preparation for measurement. When set-up time for the unit and the reagent is included, an additional 2 hours is required.
(4) In summary, the MX-50 can obtain a moisture ratio that is equal to or better than that of the KF when measuring low-moisture plastics like PET. Furthermore, it was confirmed that the MX-50 has better reliability (accuracy) and lower variance. Finally, it has much simpler operation and can greatly reduce measurement time.

## 3. Typical measurement results



∗Data from *Moisture_data.html* in *WinCT-MoistureVer.2.20M*

### 1. Household articles

| No. | Sample | Wt. (g) | Measurement Mode | Pan Temp. (℃) | Meas. Time (min) | Moisture Content | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mean Value (%) | Repeat-ability (%) | CV Value (%) | |
| 1 | Tobacco | 1 | Standard-MID | 100 | 6.5 | 10.58 | 0.339 | 3.2 | Leaves shredded for testing. Strong smell emitted during heating. |
| 2 | Dried dog food | 1 | Standard-MID | 160 | 9.2 | 8.68 | 0.059 | 0.68 | Sample was crushed with a hand mixer. Strong smell emitted during heating. |
| 3 | Toothpaste | 1 | Standard-MID | 180 | 6.4 | 36.43 | 0.472 | 1.30 | Sample was spread evenly on the pan. |
| 4 | Laundry starch (liquid) | 1 | Standard-MID | 200 | 5.5 | 93.38 | 0.170 | 0.18 | Glass fiber sheet was used. |
| 5 | Starch glue (paste) | 5 | Standard-MID | 200 | 14 | 83.34 | 0.102 | 0.12 | Sample was spread evenly on the pan. |
| 6 | Bond (paste) | 1 | Standard-MID | 200 | 9.7 | 61.3 | 0.309 | 0.50 | Sample was spread evenly on the pan. |
| 7 | Hand soap (liquid) | 1 | Standard-MID | 200 | 6 | 92.01 | 0.157 | 0.17 | Glass fiber sheet was used. |
| 8 | Lipstick | 1 | Standard-MID | 100 | 1.9 | 0.778 | 0.1938 | 24.91 | Sample was spread directly on the pan. |
| 9 | Liquid foundation | 1 | Standard-MID | 140 | 12.6 | 75.93 | 0.126 | 0.17 | Glass fiber sheet was used. |
| 10 | Silver fir chip (dried) | 1 | Standard-MID | 200 | 3.7 | 11.17 | 0.081 | 0.73 | |
| 11 | Silica sand | 10 | Standard-HI | 200 | 2.3 | 0.498 | 0.0741 | 14.88 | |
| 12 | Cement (powder) | 5 | Standard-MID | 200 | 3 | 0.408 | 0.0222 | 5.44 | |
| 13 | Putty (paste) | 1 | Standard-MID | 200 | 7.3 | 33.73 | 0.549 | 1.63 | |
| 14 | Synthetic resin paint (aqueous acrylic fluid) | 1 | Standard-MID | 200 | 13.6 | 53.93 | 0.150 | 0.28 | Glass fiber sheet was used. |
| 15 | Copying paper | 1 | Standard-MID | 200 | 2.8 | 4.69 | 0.174 | 3.71 | Sample was cut into small bits. |
| 16 | Cardboard | 1 | Standard-MID | 100 | 4.2 | 6.66 | 0.109 | 1.64 | Sample was cut into small bits. |

## 2. Food A (grain, beans, sea foods, seasonings, spices, and flavoring)

| No. | Sample | Wt. (g) | Measurement Mode | Pan Temp. (℃) | Meas. time (min) | Moisture Content | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mean Value (%) | Repeat-ability (%) | CV Value (%) | |
| **17** | Corn grits (powder) | **5** | Standard-MID | **160** | **17.5** | **12.06** | **0.072** | **0.6** | |
| **18** | Corn starch (powder) | **5** | Standard-MID | **200** | **7.1** | **12.74** | **0.137** | **1.08** | |
| **19** | Starch | **5** | Standard-MID | **180** | **7.8** | **15.95** | **0.157** | **0.99** | |
| **20** | Buckwheat flour | **5** | Standard-MID | **180** | **10.2** | **15.13** | **0.191** | **1.26** | |
| **21** | Soft flour | **5** | Standard-MID | **200** | **7.3** | **13.03** | **0.260** | **2.00** | |
| **22** | Rice flour | **5** | Standard-MID | **200** | **7.6** | **12.89** | **0.134** | **1.04** | |
| **23** | Oats | **5** | Standard-MID | **200** | **13.7** | **13.56** | **0.066** | **0.49** | |
| **24** | Pre-processed oats (grain) | **1** | Standard-MID | **160** | **19.7** | **11.8** | **0.352** | **2.98** | |
| **25** | White rice | **5** | Standard-MID | **200** | **14.3** | **15.88** | **0.198** | **1.25** | Sample was crushed with hand mixer. |
| **26** | Pre-washed rice | **1** | Standard-MID | **200** | **9.4** | **16.08** | **0.214** | **1.33** | |
| **27** | Packaged rice | **1** | Standard-MID | **200** | **15.3** | **64.51** | **0.384** | **0.60** | |
| **28** | Soybean powder | **5** | Standard-MID | **160** | **8.2** | **9.92** | **0.061** | **0.61** | |
| **29** | Cashew nuts | **5** | Standard-MID | **140** | **8.5** | **3.04** | **0.010** | **0.33** | Sample was crushed with hand mixer. |
| **30** | Butter peanuts | **5** | Standard-MID | **140** | **9.6** | **2.1** | **0.077** | **3.67** | Sample was crushed with hand mixer. |
| **31** | Ground coffee beans (powder) | **5** | Standard-MID | **140** | **9.8** | **4.43** | **0.036** | **0.81** | |
| **32** | Dried squid | **2** | Standard-MID | **180** | **20.5** | **26.21** | **0.312** | **1.19** | Sample was cut into small bits. |
| **33** | Dried squid (cooked) | **2** | Standard-MID | **140** | **16.5** | **18.55** | **0.324** | **1.75** | Sample was cut into small bits. |
| **34** | Dried sardine | **2** | Standard-MID | **160** | **8.3** | **17.28** | **0.235** | **1.36** | Sample was crushed with hand mixer. |
| **35** | Dried young sardine | **5** | Standard-MID | **200** | **15.3** | **70.23** | **0.246** | **0.35** | |
| **36** | Dried bonito fish flakes | **1** | Standard-MID | **120** | **6.0** | **14.69** | **0.770** | **5.24** | Sample was crushed with hand mixer. |
| **37** | Fish sausage | **2** | Standard-MID | **200** | **15.6** | **78.02** | **0.227** | **0.29** | Sample was cut into small bits. |

| No. | Sample | Wt. (g) | Measurement Mode | Pan Temp. (℃) | Meas. time (Min) | Moisture Content | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mean Value (%) | Repeat-ability (%) | CV Value (%) | |
| **38** | Sugar crystals (powder) | **5** | Standard-MID | **160** | **1.7** | **0.162** | **0.0130** | **8.02** | |
| **39** | Soft brown sugar (powder) | **5** | Standard-MID | **160** | **5.4** | **0.973** | **0.0386** | **3.97** | |
| **40** | Seasoned salt | **5** | Standard-MID | **100** | **1.1** | **0.086** | **0.0151** | **17.56** | |
| **41** | Salt | **5** | Standard-MID | **200** | **1.7** | **0.16** | **0.0082** | **5.00** | |
| **42** | Flavor seasoning | **5** | Standard-MID | **100** | **8.5** | **1.55** | **0.02** | **1.29** | |
| **43** | Ketchup | **1** | Standard-MID | **160** | **16.1** | **70.42** | **0.643** | **0.91** | Sample was pressed between two glass fiber sheets. |
| **44** | Mayonnaise (egg yolk type) | **1** | Standard-MID | **160** | **8.5** | **22.00** | **0.050** | **0.23** | |
| **45** | Pepper (coarsely ground) | **5** | Standard-MID | **160** | **15.9** | **12.23** | **0.142** | **1.16** | |
| **46** | Chili pepper powder | **5** | Standard-MID | **120** | **17.3** | **5.81** | **0.060** | **1.03** | |
| **47** | Seasoned chili pepper powder | **5** | Standard-MID | **120** | **16.9** | **4.9** | **0.085** | **1.73** | |
| **48** | Powder mustard | **5** | Standard-MID | **140** | **9.3** | **4.76** | **0.051** | **1.07** | |
| **49** | Powder horse radish | **5** | Standard-MID | **140** | **11.4** | **3.7** | **0.082** | **2.22** | |
| **50** | Grated horse radish (paste) | **1** | Standard-MID | **200** | **15.1** | **39.07** | **0.123** | **0.32** | Sample was spread on glass fiber sheet and crushed. |
| **51** | Grated ginger (paste) | **1** | Standard-MID | **200** | **11.9** | **84.77** | **0.439** | **0.52** | |
| **52** | Dijon mustard (granular paste) | **1** | Standard-MID | **200** | **13.5** | **54.55** | **0.416** | **0.76** | |
| **53** | Citric acid | **5** | Standard-MID | **100** | **7.2** | **4.54** | **0.210** | **4.63** | |
| **54** | Anhydrous glucose | **5** | Standard-MID | **140** | **1.7** | **0.696** | **0.0054** | **0.78** | |

### 3. Food B (processed foods, dairy products, snacks and sweets, beverages, and others)

| No. | Sample | Wt. (g) | Measurement Mode | Pan Temp. (℃) | Meas. time (Min) | Moisture Content | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mean Value (%) | Repeat-ability (%) | CV Value (%) | |
| **55** | Bread | **1** | Standard-MID | **160** | **7.3** | **36.65** | **0.550** | **1.50** | Sample was broken into bits. |
| **56** | Bread crumbs | **1** | Standard-MID | **200** | **6.2** | **32.36** | **0.505** | **1.56** | |
| **57** | Dried soup | **5** | Standard-MID | **140** | **14.1** | **4.73** | **0.079** | **1.67** | |
| **58** | Instant bean paste soup | **1** | Standard-MID | **160** | **12.9** | **63.43** | **0.728** | **1.15** | Sample was pressed between two glass fiber sheets. |
| **59** | Instant Chinese noodles | **2** | Standard-MID | **140** | **9.6** | **1.53** | **0.091** | **5.96** | Sample was crushed by light tapping. |
| **60** | Crouton | **2** | Standard-MID | **160** | **8.4** | **5.68** | **0.119** | **2.10** | Sample was crushed by light tapping. |
| **61** | Brown rice cereal | **2** | Standard-MID | **160** | **7.9** | **4.42** | **0.071** | **1.61** | Sample was crushed by light tapping. |
| **62** | Dried spaghetti | **2** | Standard-MID | **200** | **15.8** | **13.7** | **0.211** | **1.54** | Sample was crushed by light tapping. |
| **63** | Dried wheat noodle | **5** | Standard-MID | **200** | **20** | **13.36** | **0.109** | **0.82** | Sample was cut to about 3cm. |
| **64** | Dried bean starch vermicelli | **2** | Standard-MID | **200** | **15.8** | **14.8** | **0.150** | **1.01** | Sample was cut to about 3cm. |
| **65** | Dried brown seaweed | **1** | Standard-MID | **200** | **9.2** | **11.49** | **0.367** | **3.19** | Sample was crushed with hand mixer. |
| **66** | Wood ear mushroom (sliced) | **2** | Standard-MID | **180** | **18.3** | **13.13** | **0.227** | **1.73** | Sample was cut to about 3cm. |
| **67** | Beef jerky | **2** | Standard-MID | **200** | **26.7** | **27.65** | **0.243** | **0.88** | Sample was cut into small bits. |
| **68** | Rice cracker | **5** | Standard-MID | **140** | **17.1** | **6.93** | **0.045** | **0.65** | Sample was crushed by light tapping. |
| **69** | Cookie | **5** | Standard-MID | **140** | **5.5** | **2** | **0.054** | **2.70** | Sample was crushed by light tapping. |
| **70** | Caramel | **2** | Standard-MID | **140** | **16.4** | **5.94** | **0.071** | **1.20** | Sample was stretched to 1mm thick and then placed on a glass fiber sheet. |
| **71** | Banana chips (dried slice) | **1** | Standard-MID | **180** | **7.0** | **4.53** | **0.060** | **1.32** | Sample was crushed by light tapping. |
| **72** | Potato chips | **5** | Standard-MID | **140** | **9.3** | **1.88** | **0.054** | **2.87** | Sample was crushed by light tapping. |
| **73** | Snack (shrimp flavor) | **5** | Standard-MID | **160** | **6.4** | **2.54** | **0.043** | **1.69** | Sample was crushed by light tapping. |
| **74** | Snack (instant fried noodle) | **5** | Standard-MID | **140** | **8.7** | **1.31** | **0.039** | **2.98** | Sample was crushed by light tapping. |
| **75** | Jam | **1** | Standard-MID | **160** | **17.0** | **33.96** | **0.109** | **0.32** | |

| No. | Sample | Wt. (g) | Measurement Mode | Pan Temp. (℃) | Meas. time (Min) | Moisture Content | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mean Value (%) | Repeat-ability (%) | CV Value (%) | |
| **76** | Honey (drying temp., 120℃) | **1** | Standard-MID | **120** | **20.3** | **17.76** | **0.282** | **1.59** | Sample was placed on a glass fiber sheet. |
| **77** | Honey (drying temp., 140℃) | **1** | Standard-MID | **140** | **14.5** | **19.38** | **0.539** | **2.78** | Sample was placed on a glass fiber sheet. |
| **78** | Honey (drying temp., 160℃) | **1** | Standard-MID | **160** | **20.4** | **22.92** | **1.599** | **6.98** | Sample was placed on a glass fiber sheet. |
| **79** | Sweetened Condensed milk | **1** | Standard-MID | **140** | **11.9** | **25.59** | **0.400** | **1.56** | Sample was placed on a glass fiber sheet. |
| **80** | Milk (with vegetable oil) | **1** | Standard-MID | **200** | **4.5** | **61.83** | **0.491** | **0.79** | Glass fiber sheet was used. |
| **81** | Fat spread | **1** | Standard-MID | **140** | **5.8** | **28.67** | **0.060** | **0.21** | |
| **82** | Butter (solid, salted) | **1** | Standard-MID | **140** | **4.1** | **14.94** | **0.186** | **1.24** | |
| **83** | Grated cheese | **1** | Standard-MID | **160** | **8.1** | **10.65** | **0.252** | **2.37** | |
| **84** | Skimmed milk | **2** | Standard-MID | **140** | **16.7** | **6.49** | **0.255** | **3.93** | |
| **85** | Modified powdered milk (for nursing) | **2** | Standard-HI | **120** | **6.7** | **3.29** | **0.015** | **0.46** | |
| **86** | Milk | **1** | Standard-MID | **140** | **6.7** | **87.11** | **0.069** | **0.08** | Glass fiber sheet was used. |
| **87** | Yogurt A | **1** | Standard-MID | **160** | **11.5** | **81.17** | **0.383** | **0.47** | Glass fiber sheet was used. |
| **88** | Yogurt B | **1** | Automatic (0.5%/min) | **180** | **5.4** | **88.07** | **0.209** | **0.24** | Sample was flattened between a folded glass fiber sheet. |
| **89** | Soy milk | **1** | Standard-MID | **180** | **5.6** | **90.11** | **0.142** | **0.16** | Glass fiber sheet was used. |
| **90** | Green tea leaves | **5** | Standard-MID | **140** | **11.6** | **5.53** | **0.023** | **0.42** | Sample was broken up with hand mixer. |
| **91** | Instant coffee A | **1** | Standard-MID | **120** | **7.1** | **7.66** | **0.100** | **1.30** | |
| **92** | Instant coffee B | **4** | Standard-MID | **100** | **5.9** | **2.06** | **0.055** | **12.67** | |
| **93** | Orange juice (from concentrate) | **1** | Standard-MID | **140** | **7.3** | **89.48** | **0.209** | **0.23** | Glass fiber sheet was used. |
| **94** | Sports drink (powdered) | **5** | Standard-MID | **120** | **2.7** | **0.408** | **0.0476** | **11.67** | |
| **95** | Sports drink (jelly) | **1** | Standard-MID | **140** | **17.5** | **76.3** | **0.285** | **0.37** | Glass fiber sheet was used. |
| **96** | Agar powder | **5** | Standard-MID | **180** | **8.5** | **17.76** | **0.125** | **0.70** | |
| **97** | Gelatin (powder) | **5** | Standard-MID | **200** | **15.4** | **16.03** | **0.223** | **1.39** | |

## 4. Chemicals and industrial products

| No. | Classifi-cation | Sample | Wt. (g) | Measurement Mode | Pan Temp. (℃) | Meas. time (Min) | Moisture Content | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Mean Value (%) | Repeat-ability (%) | CV Value (%) | |
| **98** | Chemicals | Skin-care cream (paste) | **1** | Standard-MID | **160** | **16** | **77.06** | **0.543** | **0.70** | Sample was flattened between a folded glass fiber sheet. |
| **99** | Chemicals | Sodium tartrate dihydrate | **5** | Standard-MID | **160** | **6.8** | **15.74** | **0.010** | **0.06** | |
| **100** | Chemicals | Cellulose | **5** | Standard-MID | **180** | **5.2** | **4.37** | **0.136** | **3.11** | |
| **101** | Chemicals | Calcium stearate | **5** | Standard-MID | **180** | **7.6** | **2.9** | **0.03** | **1.03** | Strong smell emitted during heating. |
| **102** | Chemicals | Zinc oxide | **5** | Standard-HI | **200** | **2.1** | **0.148** | **0.0084** | **5.68** | Karl Fischer method; Temp: 200 ºC; 2 g sample; 5 measurements: Average moisture content: 0.080%, Repeatability: 0.0099%; Average measurement time: 9.2 min. |
| **103** | Chemicals | Aluminum oxide | **5** | Standard-HI | **200** | **2.4** | **0.098** | **0.013** | **13.27** | |
| **104** | Chemicals | Magnesium oxide | **2** | Standard-HI | **200** | **5.2** | **1.52** | **0.164** | **10.79** | |
| **105** | Chemicals | Talc | **5** | Standard-HI | **200** | **2.5** | **0.144** | **0.0114** | **7.92** | |
| **106** | Chemicals | Calcium Carbonate | **5** | Standard-Hi | **200** | **3.1** | **0.228** | **0.0205** | **8.99** | |
| **107** | Industrial products | Charcoal (Powder) | **1** | Standard-MID | **200** | **2.5** | **11.24** | **0.591** | **5.26** | |
| **108** | Industrial products | Activated charcoal (Particulate, for deodorant use) | **5** | Standard-MID | **120** | **6.6** | **9.96** | **0.142** | **1.43** | |
| **109** | Industrial products | Silica gel (particulate) | **5** | Standard-MID | **200** | **5.2** | **11.74** | **0.072** | **0.61** | Left at room temperature (23℃) for 24 hours. |
| **110** | Industrial products | Silica gel (tablet) | **3** | Standard-MID | **200** | **4.7** | **8.25** | **0.068** | **0.82** | Left at room temperature (23℃) for 24 hours. |
| **111** | Industrial products | Printer toner (powder, black) | **5** | Standard-MID | **100** | **1.6** | **0.298** | **0.0130** | **4.36** | |

## 5. Plastic, electronic parts and rubber

| No. | Classifi-cation | Sample | Wt. (g) | Measurement Mode | Pan Temp. (℃) | Meas. time (Min) | Moisture Content | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Mean Value (%) | Repeat-ability (%) | CV Value (%) | |
| **112** | Plastic | Polyethylene terephthalate pellet | **10** | Standard-HI | **180** | **6.8** | **0.298** | **0.0045** | **1.34** | Karl Fischer method; Temp: 180 ºC; 0.3 g sample; 5 measurements: Average moisture content: 0.307%; Repeatability: 0.0065%, Average measurement time: 19.1 min. |
| **113** | Plastic | ABS resin pellet | **10** | Automatic (0.005% /min) | **140** | **12.1** | **0.425** | **0.0093** | **2.19** | Karl Fischer method; Temp: 140 ºC; 0.2 g sample; 4 measurements: Average moisture content: 0.27%; Repeatability: 0.0177%; Average measurement time: 15.7 min. |
| **114** | Plastic | Poly-methylmethacrylate resin pellet | **10** | Automatic (0.005% /min) | **100** | **19.4** | **0.488** | **0.015** | **3.07** | Strong smell emitted during heating. Karl Fischer method; Temp: 100 ºC; 0.2 g sample; 4 measurements: Average moisture content: 0.301%; Repeatability: 0.0131%; Average measurement time: 30.4 min. |
| **115** | Electronic parts | CPU (100 pin, plastic QFP, 14 x 20 mm) | **10** | Standard-HI | **120** | **1.7** | **0.064** | **0.0055** | **8.59** | Left in a thermostatic chamber of 80% RH and 30 ℃ for 48 hours. |
| **116** | Rubber | Ground tire | **5** | Standard-MID | **200** | **4.3** | **22.3** | **0.08** | **0.36** | Sample was crushed finely. |
| **117** | Sewage | Sewage (human waste, liquid) | **1** | Standard-MID | **140** | **5.7** | **99.14** | **0.233** | **0.24** | Glass fiber sheet was used. Strong smell emitted during heating. |
| **118** | Sewage | Sewage (Human waste, dehydrated paste) | **5** | Standard-MID | **200** | **16.3** | **86.64** | **0.560** | **0.65** | Strong smell emitted during heating. |

## B. Data analysis

### 1. Windows™ communication software: WinCT-Moisture

WinCT-Moisture enables easy transfer of measurement data via RS-232C from A&D MS/MX/MF/ML heating and drying moisture analyzers to PCs for storage and analysis.
WinCT-Moisture (CD-ROM) is included with the MS and MX, but it can also be obtained as Accessory No. AX-MX-42.
WinCT-Moisture Windows data transmission software includes the following four applications along with measurement data of 100 typical samples.

(1) Data transmission applications

RsFig --- Graphically displays moisture content measurement processes and results
RsTemp--- Automatically determines the heating temperature of samples
RsCom --- Sends and receives data
RsKey --- Transfers data

| Software | Details |
|---|---|
| RsFig | RsFig receives data from the MS/MX/MF/ML via RS-232C and displays the data in graphs in real time. Users can observe the entire change process of the moisture content and grasp the process in which the change in moisture content drops off (the convergence process).<br>Multiple graphs can be overlaid so data from measurements under different heating temperatures can be shown in a single graph. Furthermore, data can be saved as CSV files. These features make this software very useful for examining conditions of measuring moisture content. |
| RsTemp | RsTemp automatically determines a suitable heating temperature for measuring sample moisture content by raising the heating temperature of the MS/MX/MF/ML by 20 ºC every 5 minutes, from 100 ºC to 200 ºC. The heating temperature can be automatically determined in about 30 min. (The parameters for the heating pattern can be changed when needed.)<br>Moisture content (M) and moisture loss (dM/dt) are displayed in graphs during operation (measurement). Measurement data can be saved as CSV files.<br>RsTemp is very useful for investigating the optimal heating temperature for samples.<br>**Patent approved* |
| RsCom | Sends and receives data between the MS/MX/MF/ML and PC via RS-232C. RsCom is useful for controlling the MS/MX/MF/ML. Recorded data can be stored as text files. GLP output data can also be received from the moisture analyzer. |
| RsKey | Transfers data from the MS/MX/MF/ML to commercial application software (Microsoft Excel, etc.) via RS-232C. RsKey is useful when editing data with other application software.<br>Output data from MS/MX/MF/ML moisture analyzers can be automatically input into other applications as if it was input via a keyboard. Data can be transferred to various types of applications, including spreadsheet applications, and text editors (Word, Notepad). GLP output data can also be received from the moisture analyzer. |

(2) Moisture content measurement sample table

Moisuture_data.html

The WinCT-Moisture CD-ROM contains 118 examples of moisture content rate data measured with the MX-50. To access this data file, browse to the **English** folder on the disk and click the file named **Moisuture_data.html**. Techniques for measuring moisture with the MX-50 (including typical moisture measurement data of samples and their relevant measurement conditions) can also be found there.

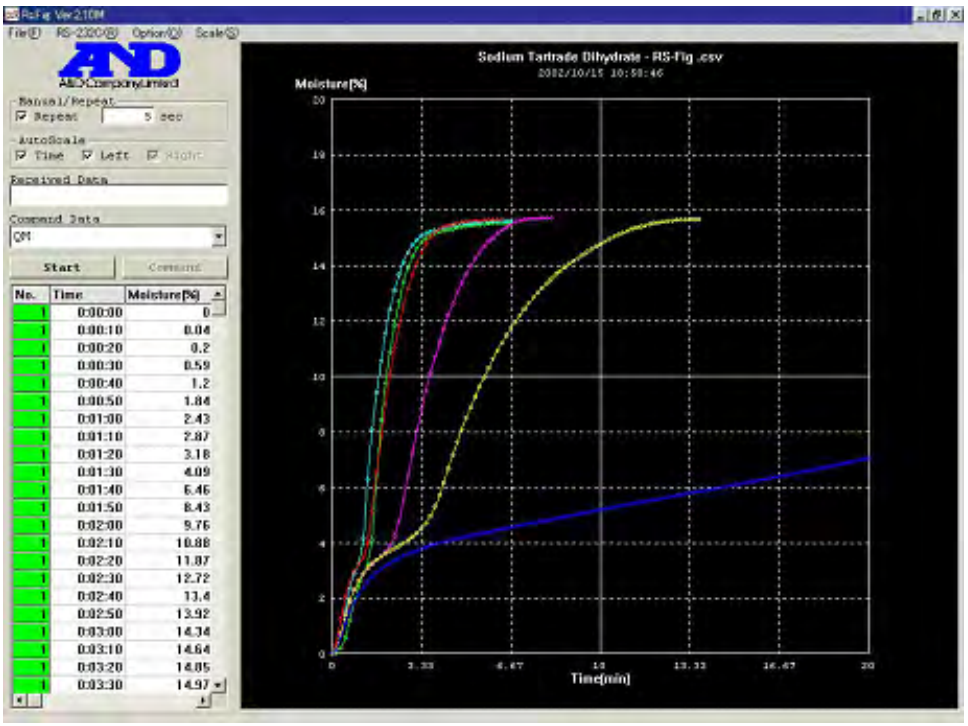
This sample data collection can also be found under Application, A. Measurement Samples, 3. Typical Measurement Results in the *Q&A Sales Handbook*.

## 2. Examples of RsFig display

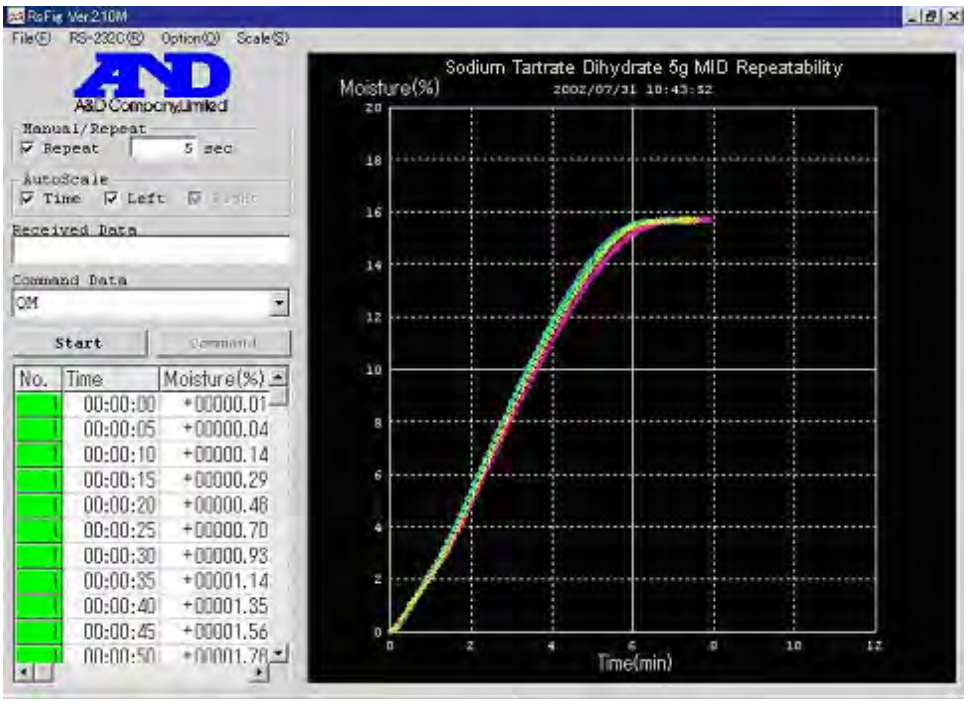


RsFig imports CSV data for moisture content rate measurement process and results and displays it as a graph.
The horizontal axis represents elapsed time (min.) from start of measurement, while the vertical axis represents moisture content rate (%). Heating evaporates moisture and the sample mass begins to decrease. The moisture content rate is calculated from this decrease and displayed as a graph. The point where changes no longer occur (where the line flattens) determines the moisture rate. Measurement results can be overlapped on a single screen (page), as shown below.

Sodium tartrate dihydrate heated from 100 ºC to 200 ºC at intervals of 20 ºC.




Sodium tartrate dihydrate measured five times at 160 ºC. All five moisture content lines overlap, which indicates high repeatability.



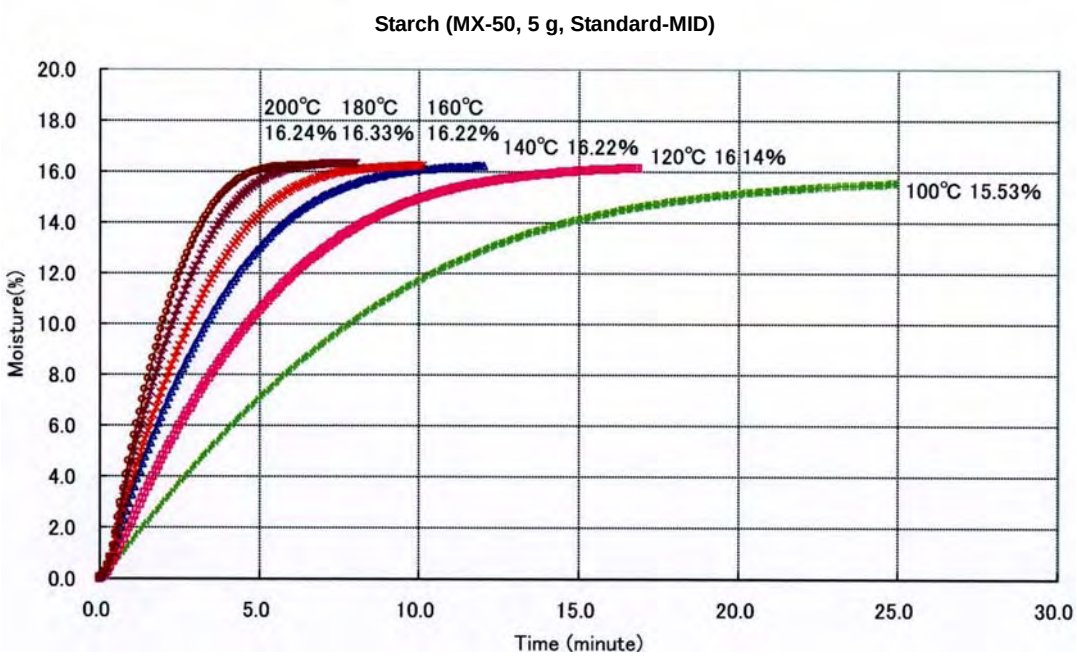
*The following are samples of measurements using RsFig. (The data was processed using Excel.)

Example 1: Final moisture content rate remains unchanged at different temperatures due to the high heat-resistance of the sample

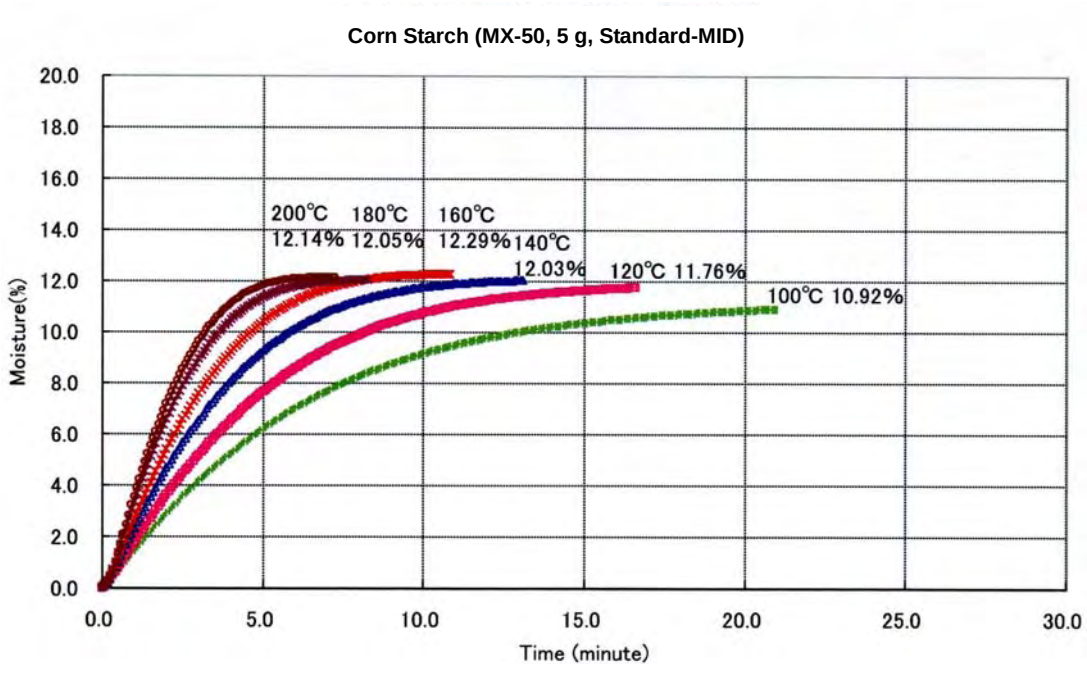
Measurement of such samples can be completed in a short time by heating at the highest possible temperature.

In addition to the items below, sodium tartrate dihydrate, hand soap, washing powder, soft flour, milk (vegetable fat), and agar powder have similar measurement processes.

**Starch (MX-50, 5 g, Standard-MID)**



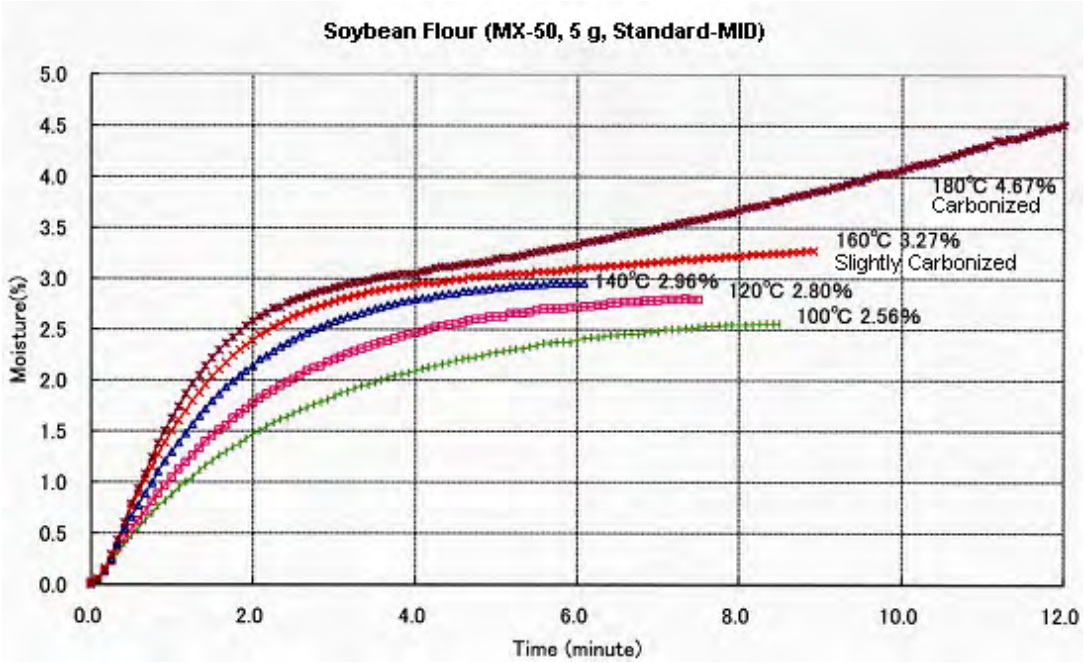

**Corn Starch (MX-50, 5 g, Standard-MID)**

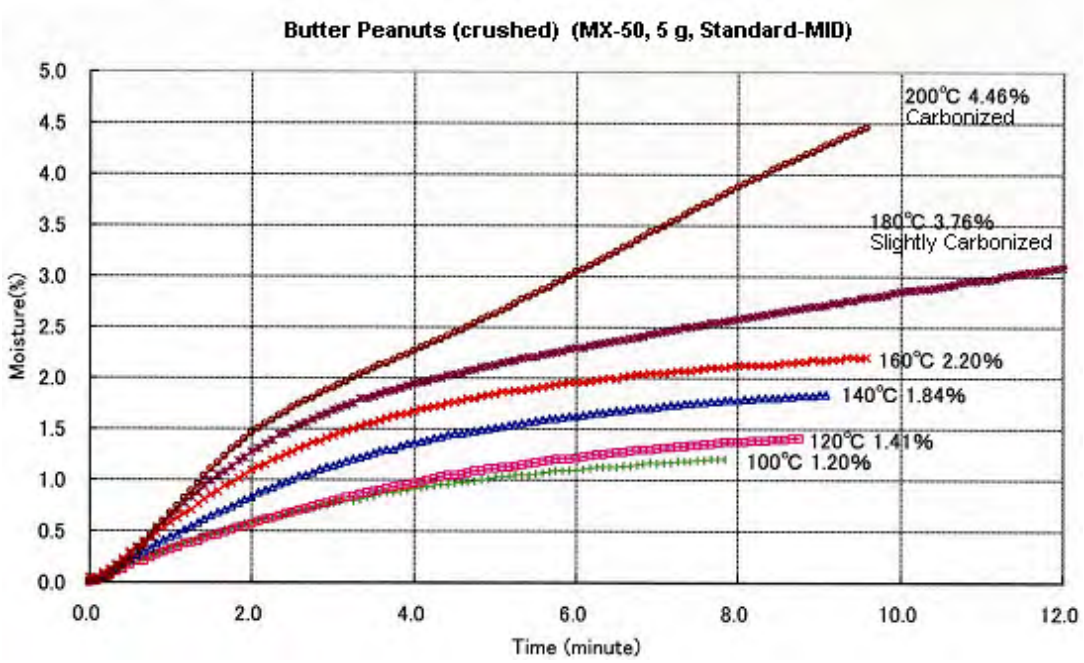


Example 2. Moisture content measurement inclines sharply above a certain temperature

Such samples should be measured at a temperature where moisture content is stabilized but before rapid changes in the curve occur.

If a moisture content curve flattens out and then rises again, materials other than water (lipids, additives, organic matter) may have evaporated. In such cases, excessively high temperatures can lead to a lack of reliability, repeatability and accuracy in measurement values.



Example 3. A stable heating condition cannot be found at any temperature

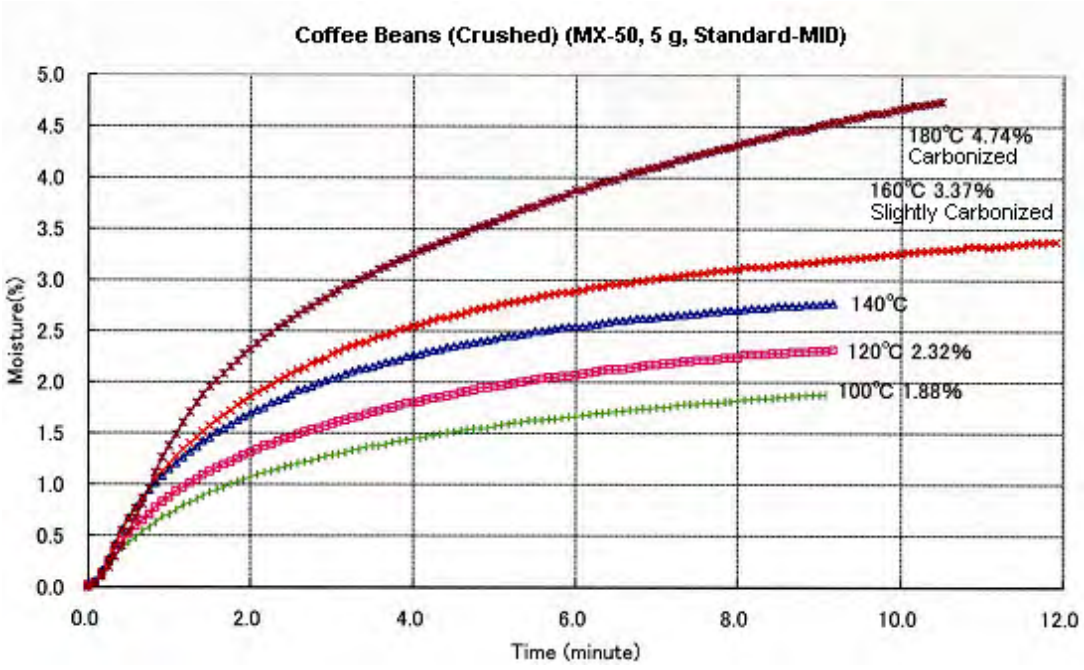
Samples like this are difficult to measure using heating and drying.

The sample may have a high content of volatile oil (fat) or its surface may carbonize easily due to its dark color.

However, it is possible to measure and evaluate moisture content of such samples by measuring under the same conditions (sample quantity, heating temperature, measurement termination condition), with previously set heating temperatures and measurement termination conditions (measurement terminates when the moisture loss value per unit of time is below certain conditions).

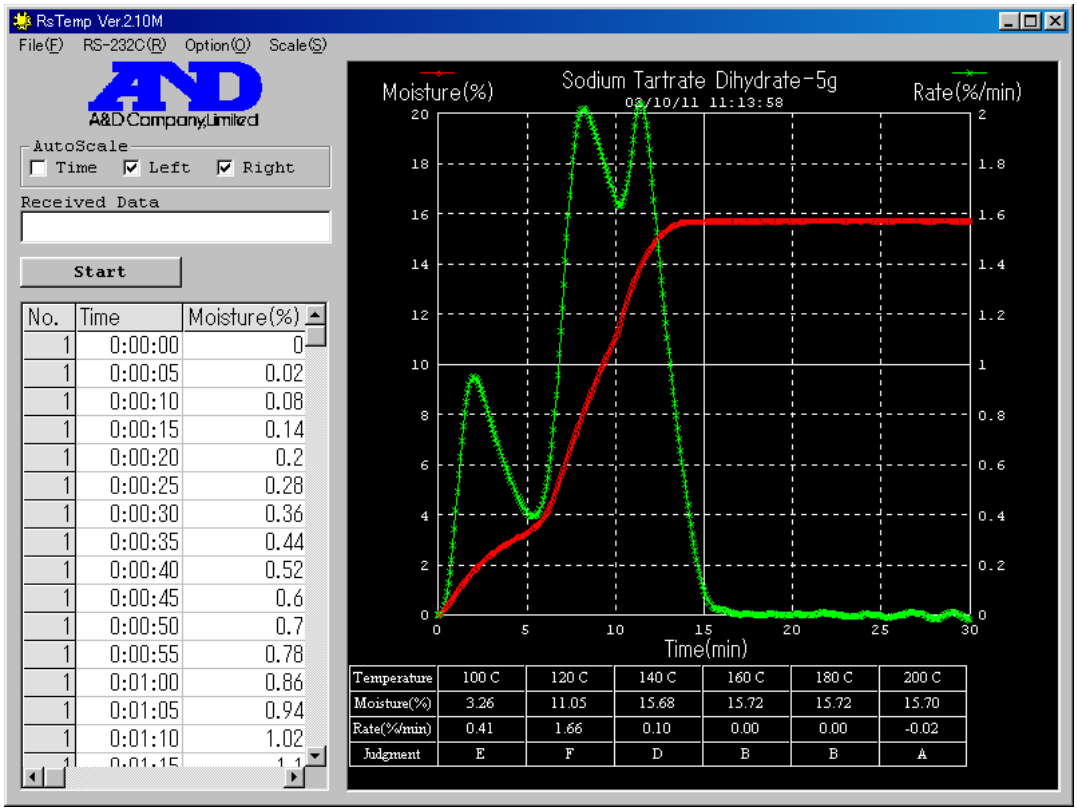
Furthermore, carbonization of sample surface can be avoided by placing a glass fiber sheet on top of the sample. This enables heating under high temperature, which may shorten measurement time and improve measurement accuracy.

Such samples include coffee beans, as shown below, as well as green tea.



## 3. Automatic determination of heating temperature by RsTemp






The RsTemp software determines the optimum heating temperature for measuring moisture content with the MS/MX/MF/ML.

The graph shown above shows an example in which sodium tartrate dihydrate is measured with RsTemp. Horizontal axis represents elapsed time. Moisture content is measured while the temperature is raised 20 ℃ every 5 minutes.

0-5 min.: 100 ℃, 5-10 min.: 120 ℃, 10-15 min.: 140 ℃, 15-20 min.: 160 ℃, 20-25 min.: 180 ℃, 25-30 min.: 200 ℃.

( Starting temperature = 100 ℃; Interval temperature=20 ℃; Interval time = 5 min.)

The red curve shows the change of moisture content and corresponds with the vertical axis at the left. This line inclination changes with changes in the heating temperature.

The green curve plots the inclination of moisture content curve (red curve) at 1-minute intervals (%/min.) and its unit is indicated by the vertical axis on the right. In other words, the green curve shows the results of primary differential of red curve (function) by time (t)=dM (t)/dt. (Temperature T remains unchanged in each heating temperature zone).

"Starting temperature", "Step temperature" and "Step time" can be changed when needed. For further information, refer to RsTemp_ReadMe.

Measured and calculated results are displayed in tables below the graph. From the top column to bottom:

Temperature: Heating temperature, which is automatically set

Moisture (%): Moisture content rate

Rate (%/min.): Change of moisture content per minute

Judgment rates the suitableness of heating temperature for moisture content measurement using an alphabetical rating (A, B, C, D, E, and F). A temperature rated “A” would be the temperature most suitable for measurement of moisture content.

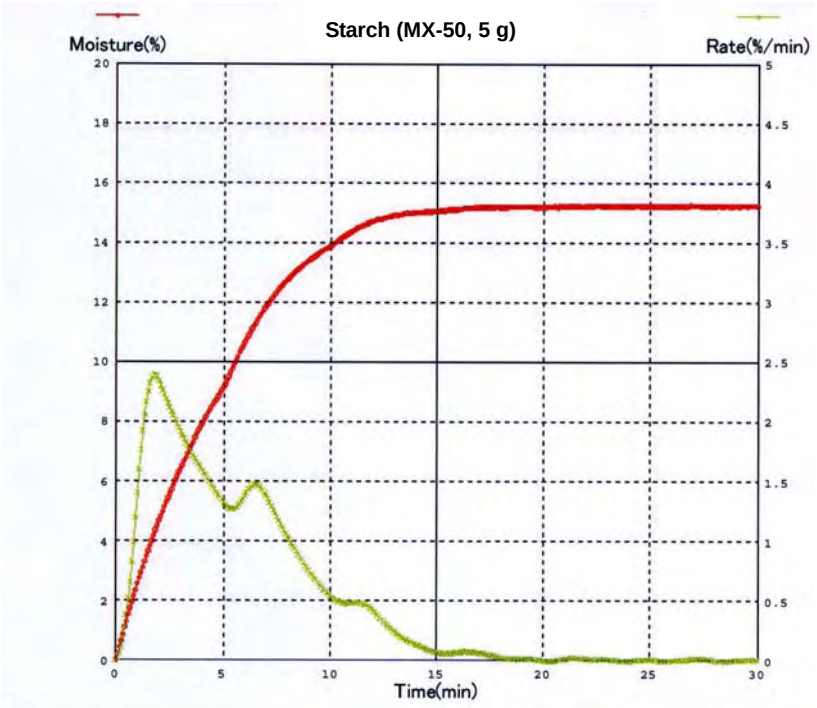
This judgment is determined from the measurement results by evaluating the stability (inclination) of the moisture content at each temperature and the primary differential value (Rate (%/min).

While RsTemp determines an appropriate temperature from these measurements and calculations, testers must also observe the sample during measurement. It is important to consider any melting, burning, odor or decomposition when deciding the optimal temperature.

Heating temperature is judged upon results of measurement performed at different temperatures, evaluating stability of moisture content rate at each temperature (inclination of moisture content rate curve, or primary derivative value Rate (%/min.)).
RsTemp is a software designed to determine heating temperature most suitable for the sample, from measured and calculated results. However, it is important to take into consideration the importance of visual and olfactory evaluation of sample condition by the test conductor, that is, to make a final decision on the suitable heating temperature based upon observance of sample description, such as dissolution, carbonization, odor, fragmentation, etc.

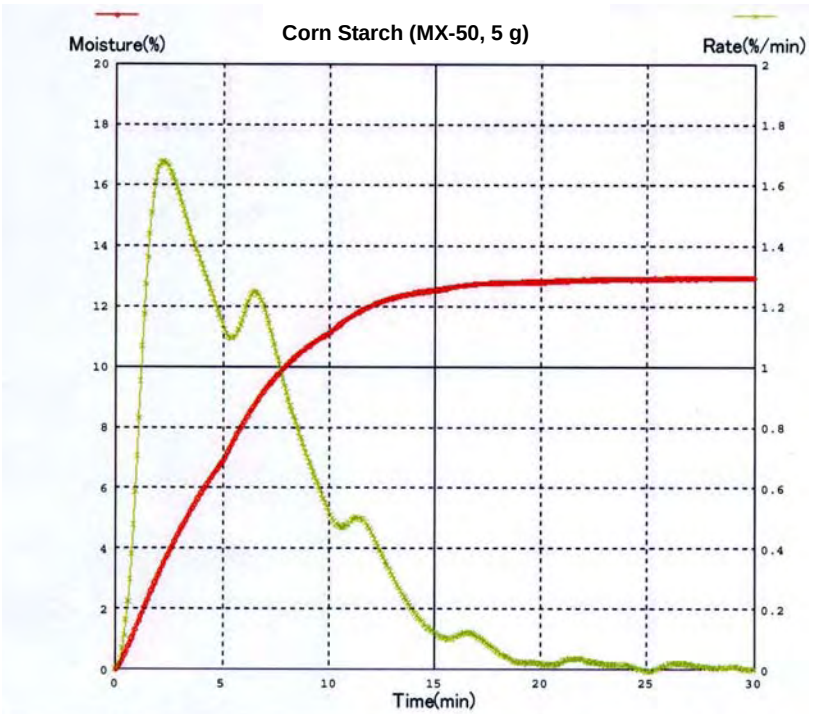
*The following are examples in which the heating temperatures were judged with RsTemp. *(Printed format)*

Example 1: Final moisture content rate remains unchanged at different temperatures due to the high heat resistance of the sample



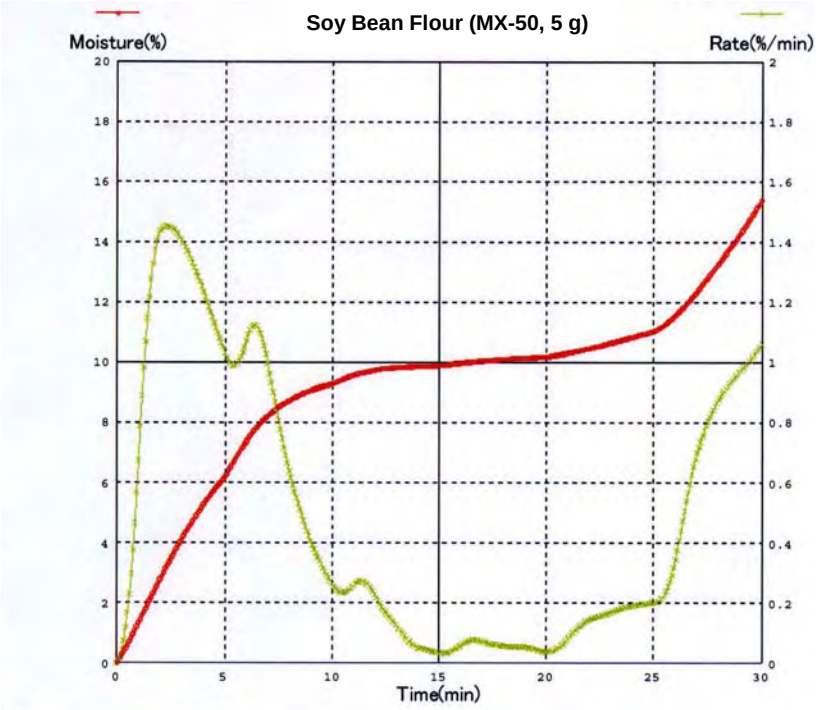

| Temperature | 100 C | 120 C | 140 C | 160 C | 180 C | 200 C |
|---|---|---|---|---|---|---|
| Moisture(%) | 9.11 | 13.88 | 15.05 | 15.20 | 15.22 | 15.22 |
| Rate(%/min) | 1.33 | 0.54 | 0.07 | 0.00 | 0.01 | 0.00 |
| Judgment | F | E | D | A | C | A |

The upper and lower graphs display measurement results for starch and cornstarch.
The graphs show that the Rate (%/min.) is stable in the higher temperature range and the value is low.
Measurement of such samples can be completed in a short time by measuring at the highest possible heating temperature.
Samples with similar measurement processes include sodium tartrate dihydrate, hand soap, washing powder, soft flour, milk (vegetable fat), and agar powder.

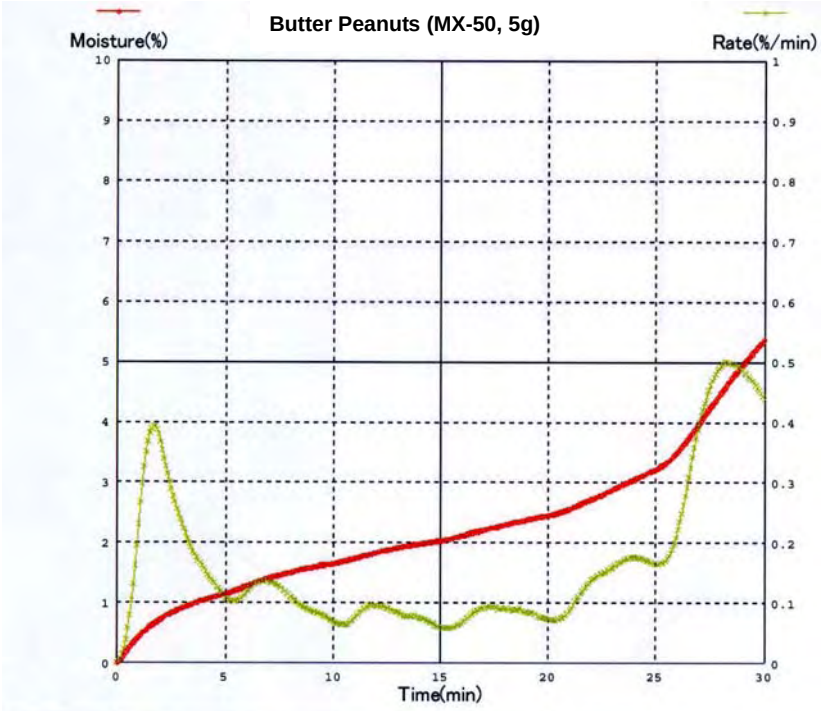



| Temperature | 100 C | 120 C | 140 C | 160 C | 180 C | 200 C |
|---|---|---|---|---|---|---|
| Moisture(%) | 6.87 | 11.10 | 12.51 | 12.79 | 12.88 | 12.93 |
| Rate(%/min) | 1.14 | 0.52 | 0.12 | 0.02 | -0.01 | 0.00 |
| Judgment | F | E | D | C | A | B |

Example 2. The moisture content curve inclines sharply above a particular heating temperature



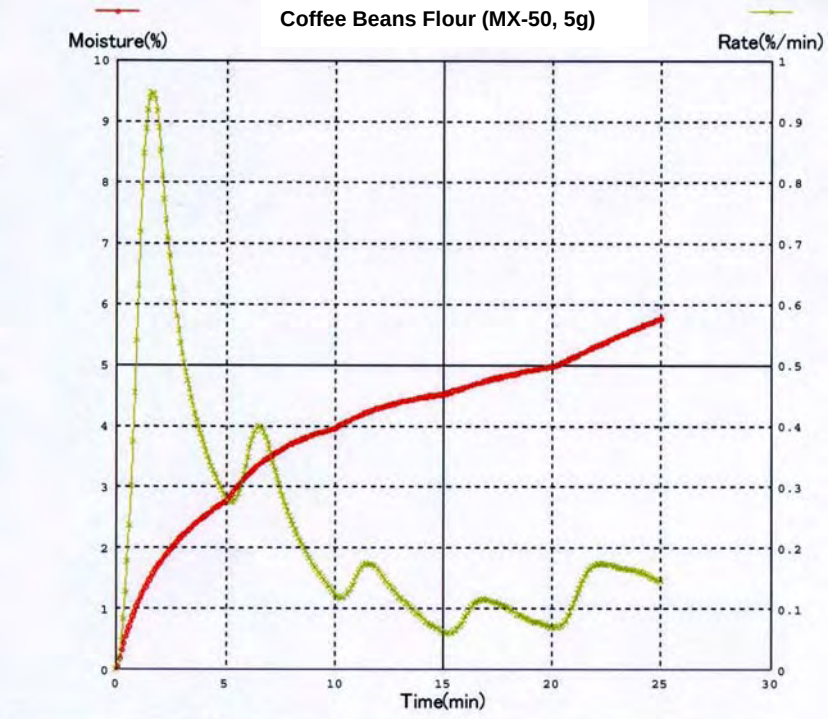

| Temperature | 100 C | 120 C | 140 C | 160 C | 180 C | 200 C |
|---|---|---|---|---|---|---|
| Moisture(%) | 6.19 | 9.25 | 9.88 | 10.17 | 11.02 | 15.39 |
| Rate(%/min) | 1.03 | 0.27 | 0.04 | 0.04 | 0.20 | 1.06 |
| Judgment | E | D | A | A | C | F |




| Temperature | 100 C | 120 C | 140 C | 160 C | 180 C | 200 C |
|---|---|---|---|---|---|---|
| Moisture(%) | 1.14 | 1.64 | 2.03 | 2.45 | 3.21 | 5.37 |
| Rate(%/min) | 0.11 | 0.07 | 0.06 | 0.07 | 0.17 | 0.44 |
| Judgment | D | B | A | B | E | F |

The upper and lower graphs display measurement results for soy powder and butter peanuts.
Rate (%/min.) increases shortly after the start of heating, then decreases, and then increases again.
The Rate likely increased above 180℃ due to an component other than water (other liquids, additives, organic matter) vaporizing, or because the sample started to carbonize.
In such cases, an excessively high temperature could lead to lack of reliability, repeatability and accuracy in measurement values.
It is recommended that such samples be measured at a temperature where moisture content is stable and before curves rapidly change.

Example 3. No temperature setting produces a heating condition for stable moisture measurement




| Temperature | 100 C | 120 C | 140 C | 160 C | 180 C | 200 C |
|---|---|---|---|---|---|---|
| Moisture(%) | 2.76 | 3.95 | 4.51 | 4.97 | 5.76 | |
| Rate(%/min) | 0.28 | 0.12 | 0.06 | 0.07 | 0.15 | |
| Judgment | E | C | A | B | D | |

This graph shows results of measurement on coffee beans.
Moisture content rate curve (red) does not stabilize to a horizontal line. The differential curve (green line) increases and decreases after the start of heating, and increases again when heated above 180 ℃. With such samples, continuous vaporization of other ingredients or carbonization is assumed to follow water vaporization.
Such samples are not suitable for measurement with heat and dry moisture analyzer.
However, it is possible to measure and evaluate moisture content of such samples by measuring under same conditions (sample quantity, heating temperature, measurement termination condition), with previously set heating temperature and measurement termination conditions. (Measurement is terminated when the time variation of the moisture loss falls below certain conditions.)
Carbonization of sample surfaces can be avoided by placing a glass fiber sheet on top of the sample, which enables heating under high temperatures. This can shorten measurement time and improve measurement accuracy.
Samples of this type include coffee beans and green tea.

## ■Maintenance

### A. Halogen lamp

| No. | Question | Answer |
|---|---|---|
| 1 | How long do the halogen lamps last? | About 5,000 hours. If you use a halogen lamp for 8 hours a day, its lifetime is about 2 years. |
| 2 | Can users exchange the halogen lamp? | Yes, it can be replaced with A&D's optional accessory AX-MX-34 for the MS/MX/MF/ML. Read the instruction manual before replacing the lamp. |

### B. Cleaning

| No. | Question | Answer |
|---|---|---|
| 1 | If the glass housing below the halogen lamp gets dirty, will the measurement of the moisture content rate be affected? | Yes, it may. Heat conduction may worsen, making it difficult to heat the sample evenly. This in turn may lengthen measurement time and lead to low repeatability.<br>The MS/MX/MF/ML is easy to clean. If glass gets stained, perform the following procedure as soon as possible.<br>1. Wait for the unit to cool down to room temperature.<br>2. Remove the 2 screws and detach the SRA unit.<br>3. Clean with a water-based or neutral detergent. Do not use organic solvents or chemical wipes.<br>(For details on how to remove the glass, refer to "How to change halogen lamps" in the Maintenance section of the instruction manual.) |

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