DLG Test Report 7273

Maschinenfabrik Bernard Krone GmbH & Co. KG

NIR Control dual

with calibration model 14.3.1

Ingredients in liquid cattle manure, liquid pig manure, mixed manure from cattle and pig manure and in liquid digestate

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KRONE NIR CONTROL DUAL WITH CALIBRATION MODEL 14.3.1

- ✓ **Ingredients in cattle manure: DM, N_{Total}, NH_4-N, P_2O_5, K_2O**
- ✓ **Ingredients in pig manure: DM, N_{Total}, NH_4-N, P_2O_5**
- ✓ **Ingredients in mixed manure form cattle and pig manure: DM, N_{Total}, P_2O_5, K_2O**
- ✓ **Ingredients in liquid digestate: DM, N_{Total}, NH_4-N, P_2O_5,**

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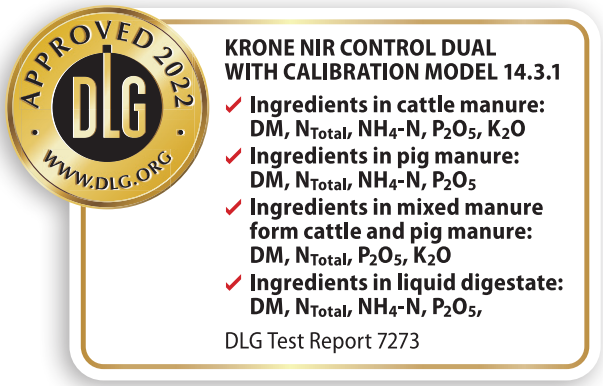
Overview



A test mark „DLG-APPROVED for individual criteria“ is awarded for agricultural products which have successfully fulfilled a scope-reduced usability testing conducted by DLG according to independent and recognised evaluation criteria. The test is intended to highlight particular innovations and key criteria of the test object. The test may contain criteria from the DLG test scope for overall tests, or focus on other value-determining characteristics and properties of the test subject. The minimum requirements, test conditions and procedures as well as the evaluation bases of the test results will be specified in consultation with an expert group of DLG. They correspond to the recognised rules of technology, as well as scientific and agricultural knowledge and requirements. The successful testing is concluded with the publication of a test report, as well as the awarding of the test mark which is valid for five years from the date of awarding.

The DLG test for **“Precision of NIR sensors for the determination of ingredients in passing liquid manure of animal origin and liquid digestate from cattle or pig manure with renewable raw materials”** was carried out on the **NIR Control dual with calibration model 14.3.1 of Maschinenfabrik Bernard Krone GmbH & Co. KG**.

The measurements for determining the contents of ingredients were carried out in in liquid cattle manure, in liquid pig manure, in liquid mixed manure from cattle and pig manure and in liquid digestate from cattle or pig manure with renewable raw materials. In each manure type, five different practice slurries were examined through the tested sensor for their levels of dry matter content (DM in weight %), total nitrogen (N_{Total} in kg/m³), ammonium nitrogen (NH_4-N in kg/m³), phosphate (phosphorous pentoxide; P_2O_5 in kg/m³), and potassium oxide (K_2O in kg/m³). During the measurements from each slurry samples were collected.

The taken samples were analyzed by a total of five different accredited specialized laboratories, preferably with wet-chemical methods. For each ingredient, the averages from the results of the laboratory analyses were calculated. For the evaluation, the differences between the value measured by the NIR Sensor and the mean value of the laboratories were determined as the relative measurement deviation. The precision of the sensor was examined at different flow rates too.

Other criteria were not tested.

Assessment in brief

On the basis of the results obtained the mobile sensor Krone NIR Control dual with calibration model 14.3.1 is awarded the DLG test mark “DLG APPROVED in single criteria” in the measurement of ingredients in liquid manures for the parameters listed in the following table 1.

Table 1:
Overview of results

DLG QUALITY PROFILE	
Ingredient	**Evaluation***
Cattle manure	
Dry Matter (DM)	✓
Total nitrogen (N_{Total})	✓
Ammonium nitrogen (NH_4N)	✓
Phosphorous Pentoxide (P_2O_5)	✓
Potassium oxide (K_2O)	✓
Pig manure	
Dry Matter (DM)	✓
Total nitrogen (N_{Total})	✓
Ammonium nitrogen (NH_4N)	✓
Phosphorous Pentoxide (P_2O_5)	✓
Mixed manure from cattle and pig manure	
Dry Matter (DM)	✓
Total nitrogen (N_{Total})	✓
Phosphorous Pentoxide (P_2O_5)	✓
Potassium oxide (K_2O)	✓
Liquid digestate from cattle or pig manure with renewable raw materials	
Dry Matter (DM)	✓
Total nitrogen (N_{Total})	✓
Ammonium nitrogen (NH_4N)	✓
Phosphorous Pentoxide (P_2O_5)	✓

* Evaluation range: Requirements fulfilled (✓) / Requirements not fulfilled (✗)

The product

Manufacturer and Applicant

Maschinenfabrik Bernard Krone GmbH & Co. KG
Heinrich-Krone-Str. 10
48480 Spelle, Germany

Product:
Krone NIR Control dual with calibration model 14.3.1

Description and technical data

The Krone NIR Control dual measuring system is a NIR (NearInfraRed) measuring system developed for the compositional analysis of organic substances, such as animal farm fertiliser and digestates.

The Krone NIR Control dual is integrated into the existing pipe system of the pumping station or the manure tank truck. To ensure error-free functionality of the sensor the installation positions specified by the manufacturer must be observed.

In addition, the manufacturer offers also an application for the determination of ingredients in passing feed if the system is attached to the spout of KRONE forage harvesters. For use in the forage harvester the Krone NIR Control dual has a DLG recognition at the dry mass determination in corn with the calibration model 'Mais 08 V3.0.1' (see DLG test report 7222).

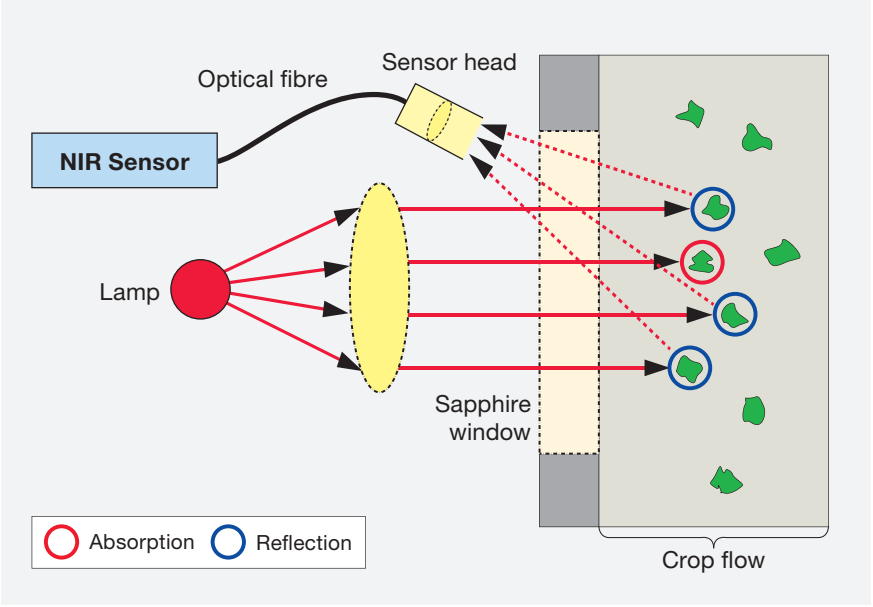
The data can be georeferenced and easily communicated for example via agrirouter to a farm management software such as Next Machine Management. The yield and nutrient maps can be merged with seed and fertilizer application maps. Through this farmers and agronomists can improve their planning for the next season.

Procedure of near-infrared measurement

The function of a NIR sensor systems is shown in Figure 2. The passing material is separated from the sensor by a sapphire window. During the NIR analysis, the passing material is irradiated with infra-red light source of known spectrum. The reflected or re-emitted light is detected. To compensate for the temperature-dependent shifts in the spectrum, the system runs regular white and dark referencing. The measurement data are processed via an evaluation unit and converted into measurement values with unit specifications in a microcomputer using the calibration models stored for the parameters to be determined.

The measurement is performed continuously on the passing material. Measuring values are output every second when in measuring mode. Depending upon the requirements, mean values for user-specific time intervals, or live values, are displayed in real time.

The manufacturer specifies the measurement ranges shown in Table 2 for calibration model 14.3.1.



Source: m-u-t GmbH

Figure 2:
Functional principle and system structure Krone NIR Control dual

Table 2:
Measurement range of Krone NIR Control dual with calibration model 14.3.1

Parameter	Value range
DM [%]	0,5 – 11,00
N_{Total} [kg/m³]	0,5 – 9,00
NH_4-N [kg/m³]	0,0 – 4,00
P_2O_5 [kg/m³]	0,0 – 6,00
K_2O [kg/m³]	0,5 – 7,00

The aim of the DLG Test "Precision of mobile sensors for the determination of ingredients in passing liquid manure of animal origin and liquid digestate" is to examine the accuracies of mobile sensors in conjunction with appropriate calibration models in comparison to laboratory analysis with officially recognized methods.

A major advantage of NIR measuring technology compared to the conventional methods for the determination of ingredients in liquid manures through sampling and laboratory analysis, consists in the immediate availability of measurement results, and in the permanent measurement of the ingredients along the complete manure volume.

The scope in the DLG Test is limited on substrates, which are described as manure according to the German Fertilizer Act, so on cattle manure, pig manure, mixed manure from cattle and pig manure, and liquid digestate from cattle or pig manure with renewable raw materials.

The DLG test is available for the measurement of the following ingredients:

- Dry matter content (DM in % Weight.)
- Total Nitrogen amount (N_{Total} in kg/m³)
- Ammonium nitrogen amount (NH_4N in kg/m³)
- Phosphate content (Phosphorous Pentoxide; P_2O_5 in kg/m³)
- Potassium (Potassium Oxide; K_2O in kg/m³)

In order to cover a wide range of applications, the test attempts to use a diverse spectrum for each type of substrate:

- Cattle manure: 4 % DM – 9 % DM, where possible from dairy cows and fattened cattles
- Pig manure: 2 % DM – 7 % DM, where possible from sow-keeping + fattened pigs
- Mixed manure from cattle and pig manure: concentration series as follows
  10 %cattle : 90 %pig / 30 %cattle : 70 %pig / 50 %cattle : 50 %pig / 70 %cattle : 30 %pig / 90 %cattle : 10 %pig
- Liquid digestate from cattle or pig manure with renewable raw materials: 5 % DM – 8 % DM

The DLG approval can be awarded for individual types of manure and individual ingredients. To get a DLG recognition, at least the requirements for the measurement of the total nitrogen content (N_{Total}) need to be met. When the requirements for the measurement of the total nitrogen content are met, other ingredients can be freely chosen.

The process

Depending on each type of manure (cattle manure, pig manure, mixed manure from cattle and pig manure, liquid digestate from cattle or pig manure with renewable raw materials) five individual and as diverse as possible samples are measured and sampled on different farms. For this purpose, a subset of 3 m³ to 5 m³ is pumped from the previously stirred slurry storage in an intermediate tank.

At the intermediate tank, a pump and a common piping system are installed. On the piping system one or more sensors to be tested and a bypass for sampling are attached. If necessary, a flow meter for the control of flow rates can be attached (see figure 3).

In a preliminary phase the collected manure is intensively homogenized in the intermediate tank by continuous circulation in a closed circuit.

Following this preliminary phase, the measured values of the sensor are documented. Afterwards subsamples for the reference analyses are then taken via the bypass while maintaining inflation around the closed circuit. In order to determine any possible influence on the sensor values, subsequently the flow velocity is varied and the measured values are re-documented.

The manure samples are clearly marked, frozen and stored frozen. Five suitable laboratories are commissioned with the reference analysis. Each laboratory receives partial samples of each manure. The analyses in the laboratory must be carried out using officially recognized methods, preferably wet-chemical methods.

For each manure and each ingredient, the arithmetic mean value is calculated as a reference value from the laboratory results. The assessment of accuracy is based on the relative deviations from the sensor value in comparison with the reference value.

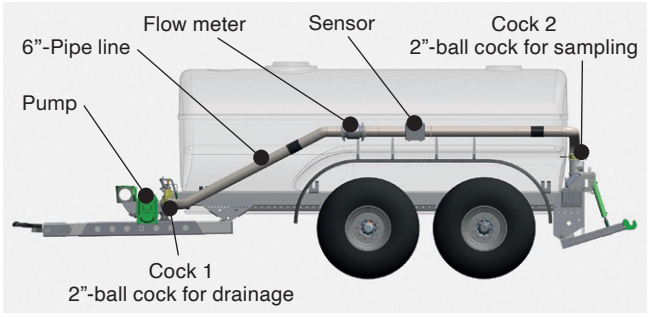


Figure 3:
Schematic structure of the DLG measuring system

Detailed account of the test results

The trials were conducted jointly with the Educational Center located at Triesdorf, Germany (Landwirtschaftliche Lehranstalten LLA, Triesdorf). Flow rates from 6 m³/min to 9 m³/min were set during the measurements. The different flow rates showed no influence on the measured values of the sensor. In table 3 the individual results are given.

Based on the obtained results, the mobile Sensor Krone NIR Control dual with calibration model 14.3.1 is awarded the test mark „DLG-APPROVED in individual criteria“ for the measurement of:

- Ingredients in liquid cattle manure: DM, N_{Total}, NH_4-N, P_2O_5, K_2O
- Ingredients in liquid pig manure: DM, N_{Total}, NH_4-N, P_2O_5
- Ingredients in mixed manure from liquid cattle and liquid pig manure: DM, N_{Total}, P_2O_5, K_2O
- Ingredients in liquid digestate from cattle or pig manure with renewable raw materials: DM, N_{Total}, NH_4-N, P_2O_5

Table 3:
Individual results

Type designation	Krone NIR Control dual with calibration model 14.3.1	Evaluation*
Installation position (tilt)		
	90°	
Installation position		
	horizontal 6" pipe	
Cattle manure		
	DM in % by weight	+
	N_{Total} in kg/m³	○
	NH_4-N in kg/m³	○
	P_2O_5 in kg/m³	○
	K_2O in kg/m³	+ +
Pig manure		
	DM in % by weight	+ +
	N_{Total} in kg/m³	○
	NH_4-N in kg/m³	○
	P_2O_5 in kg/m³	○
	K_2O in kg/m³	–
Mixed manure from cattle and pig manure		
	DM in % by weight	○
	N_{Total} in kg/m³	+ +
	NH_4-N in kg/m³	–
	P_2O_5 in kg/m³	○
	K_2O in kg/m³	+
Liquid digestate from cattle or pig manure with renewable raw materials		
	DM in % by weight	○
	N_{Total} in kg/m³	+
	NH_4-N in kg/m³	+
	P_2O_5 in kg/m³	○
	K_2O in kg/m³	–

DLG-assesment scheme:

+ + = passed, very good (4/5 value pairs within a manure type ≤ 10 % and no > 20 % rel. deviation)
+ = passed, good (4/5 value pairs within a manure type ≤ 15 % and no > 25 % rel. deviation)
○ = passed (3/5 value pairs within a manure type ≤ 25 % and no > 35 % rel. deviation)
– = failed

Summary

The sensor NIR Control dual with calibration model 14.3.1 of Maschinenfabrik Bernard Krone GmbH & Co. KG fulfilled the requirements for DLG approval in the accuracy of measurement of dry matter (DM), total nitrogen (N_{Total}), and Phosphorous Pentoxide (P_2O_5) in liquid cattle and pig manure, in mixed manure from cattle and pig manure and in liquid digestate from cattle or pig manure with renewable raw materials.

In addition, the system meets the DLG requirements for ammonium nitrogen (NH_4-N) in cattle and pig manure as well as liquid digestate from cattle or pig manure with renewable raw materials and for potassium oxide (K_2O) in cattle manure such as mixed manure from cattle and pig manure.

A major advantage of NIR measuring technology compared to the conventional methods for the determination of ingredients in liquid manures through sampling and laboratory analysis, consists in the immediate availability of measurement results, and in the permanent measurement of the ingredients along the complete manure volume.


DLG kompakt

Nr. 8/2019

Nährstoffgehalte in Gülle online mit Sensoren bestimmen

Einführung

Die Anforderungen an die Ausbringung von Gülle sind in den letzten Jahren kontinuierlich gestiegen und ein Ende dieser Entwicklung ist derzeit nicht abzusehen. Aus pflanzenbaulicher Sicht ist eine angepasste, möglichst zu jedem Zeitpunkt der Entwicklung optimale Versorgung der Pflanzen gewünscht. Ähnliches gilt aus Umweltaspekten, denn während ein Mangel an Nährstoffen die Entwicklung behindert und die zu erwartende Ernte verringert, sind Nährstoffüberschüsse vor allem deshalb unerwünscht, weil sie unter Umständen Grundwasser und Oberflächengewässer schädigen können. Dem wird in den rechtlichen Regelungen, z. B. in der Düngeverordnung (DüV) Rechnung getragen. In dieser sind aus Gründen des Grund- und Oberflächenwasserschutzes beispielsweise Grenzwerte für die Ausbringmenge und Beschränkungen der Ausbringzeiten enthalten. Insgesamt führt dies zu steigenden Anforderungen auch an die Erfassung und die Dokumentation der Nährstofffrachten.
Hinzu kommt, dass sich die Zusammensetzung von Gülle in vielen Bereichen der Landwirtschaft in den letzten Jahren sehr verändert hat. Durch Veränderungen bei den Fütterungskonzepten in der konventionellen und der biologischen Tierhaltung (z. B. N- und P-reduzierte Fütterung), Vergärung von Gülle und Festmist in Biogasanlagen, Separation und das Vermischen von Gülle ist inzwischen eine hohe Varianz an Nährstoffen anzutreffen. Aufgrund der fortschreitenden Diversifizierung wird sich dieser Trend weiter fortsetzen.
Bisher können die Nährstoffgehalte entweder aus Standard-Tabellen in die Dokumentation bzw. Bilanzierung übernommen oder durch wissenschaftlich anerkannte Methoden ermittelt werden. Die Werte aus den Standard-Tabellen bilden aber in der Regel die hohe Varianz der Nährstoffzusammensetzung auf den Betrieben nicht mehr ab. Für die Laboranalyse werden zufällige Einzelproben am Vorratsbehälter entnommen und zu einer Mischprobe zusammengeführt. Diese Mischprobe wird dann in ein geeignetes Gefäß umgefüllt und oft mit Zeitverzug an ein Labor geschickt. Die Länder geben hierzu Empfehlungen für die Vorgehensweise, um den Probennahmefehler zu reduzieren. Nach der Untersuchung der Probe im Labor, die mit verschiedenen Methoden erfolgen kann, werden nach einigen Tagen die Ergebnisse an den Landwirt zurückgegeben, der den Laborbericht dann zu Dokumentationszwecken abheftet.
Dieser Prozess von Probennahme bis Ergebnisdokumentation ist mit einigen, in Summe aber bedeutsamen Fehlerquellen behaftet – von einer unvollständigen Homogenisierung der Gülle im Lagerbehälter vor der Entnahme der Probe, über Nährstoffverluste während des Versands bis hin zu Unterschieden in den Ergebnissen zwischen verschiedenen Laboren. Hinzu kommt der Zeitfaktor, denn manchmal ist die Gülle bereits ausgebracht, bevor das Ergebnis der Untersuchung vorliegt, obwohl die aktuell gültige Düngeverordnung aus 2017 eine Analyse der Gülle vor der Ausbringung fordert. Somit müsste man die Gülle mit entsprechend zeitlichem Vorlauf vor der Ausbringung separat homogenisieren und beproben. Die oben genannten Anforderungen werden also mit den derzeit üblichen Vorgehensweisen nicht immer in ausreichender Weise erfüllt. Seit kurzem aber sind neue Technologien auf dem Markt verfügbar, die Messungen

www.DLG.org

Within the DLG Competence Center Agriculture, the DLG Expert Committee for technology in plant production among other topics deals with the application of liquid and solid manure. As an outcome from this voluntary specialist work the DLG Expert Knowledge series gives up-to-date information on 15 topic areas (download free of charge at www.DLG.org/ExpertKnowledge). Even more publications of the DLG Expert Committee can be found in German at https://www.dlg.org/de/landwirtschaft/themen/technik/technik-in-der-pflanzenproduktion/). Within the “DLG Compact” series, the 8/2019 issue with the title “Online Determination of nutrient content in liquid manure with sensors”, which was created under the leadership of the DLG Examination Commission for Fertilizer Technology in the DLG Test Center, is also available there.

Further information

Testing agency

DLG TestService GmbH,
Gross-Umstadt location, Germany

Landwirtschaftliche Lehranstalten, Triesdorf

The tests are conducted on behalf of DLG e.V.

DLG test framework

"Precision of NIR sensors for the determination of ingredients in passing liquid manure of animal origin and liquid digestate" (current as of 09/2020)

Department

Agricultural technology

Members of the competent DLG Test Commission "Fertilising Technology"

Dr. Horst Cielejewski, Chamber of Agriculture of North Rhine-Westphalia

Dr. Harm Drücker, Chamber of Agriculture of Lower Saxony

Prof. Nils Fölster, University of Osnabrück

Prof. Hans W. Griepentrog, University of Hohenheim

Dr. Fabian Lichti, State Institute of Agriculture Bavaria

Frank Reith (farmer), Groß-Umstadt

Sven Schneider (farmer and contractor), Brensbach

Peter Seeger (farmer), Otzberg

Division head

Dr. Ulrich Rubenschuh*

Test engineer(s)

Dipl. Ing. agr. Georg Horst Schuchmann

Photos and graphics

Krone, m-u-t, DLG

* Author

The DLG

In addition to being the executing body of well-known tests for agricultural engineering, farm inputs and foods, the DLG is also an open forum for the exchange of knowledge and opinions in the agricultural and food industry.

Some 180 full-time employees and more than 3,000 volunteer experts are developing solutions to current problems. The more than 80 committees, working groups and committees thereby form the basis of expertise and continuity for the professional work. At the DLG, a great deal of specialist information for agriculture is created in the form of information leaflets and working papers, as well as articles in journals and books.

DLG organises the world's leading professional exhibitions for the agriculture and food sector. This contributes to the transparent presentation of modern products, processes and services to the public. Secure the competitive edge as well as other benefits, and contribute to the expert knowledge base of the agricultural industry. Further information can be obtained under www.dlg.org/mitgliedschaft.

The DLG Test Center Technology and Farm Inputs

The DLG Test Centre Technology and Farm Inputs in Groß-Umstadt is the benchmark for tested agricultural products and farm inputs, as well as a leading testing and certification service provider for independent technology tests. The DLG test engineers precisely examine product developments and innovations by utilizing state-of-the-art measurement technology and testing methods gained from practice.

As an accredited and EU registered testing laboratory the DLG Test Center Technology and Farm Inputs offers farmers and practitioners vital information and decision support for the investment planning for agricultural technology and farm inputs through recognized technology tests and DLG testing.

Internal test code DLG: 2206-0093

DLG e.V.
Testzentrum Technik & Betriebsmittel
Max-Eyth-Weg 1 • 64823 Groß-Umstadt • Germany
Telefon: +49 69 24788-600 • Fax: +49 69 24788-690
Tech@DLG.org • www.DLG.org