Site-Specific Management Guidelines

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Yield Monitors—Basic Steps to Ensure System Accuracy and Performance

Summary

According to today's yield monitor manufacturers, most users should obtain accuracy within +/- 3 percent, if the system is properly installed, maintained and calibrated. Items that operators must be conscious of and attend to for good results can be summarized as follows:

- Proper calibration of the mass-flow sensor using multiple loads acquired according to the manufacturer's recommendations.
- Inspection of the system sensors, particularly those affected by crop conditions, during the harvest.
- Verification and, if necessary, calibration of the ground speed sensor.
- Verification and calibration of moisture and temperature sensors.
- Correct entry of the operating information such as crop type, field, and header width for each field into the system console.
- Proper use of the software to extract and process the yield data.

New technology often requires time and experience to ensure all things are operating at peak performance. The items discussed here are lessons learned with field experience.

Introduction

It is estimated that 48 million of the 160 million corn and soybean acres in the U.S. were harvested using a combine equipped with a yield monitor in 2000. In order to get the most value from yield monitor information, correct calibration and installation are critical. Hardware system operations, conditions of the crop, and the system software influence yield monitor accuracy. The goal of this guideline is to detail the steps required to ensure accurate yield monitor operation.

Yield Monitoring Equipment

The most widely used combine yield monitor consists of the following equipment:

- Impact plate or mass flow sensor to measure grain flow
- Moisture sensor to measure grain moisture
- Speed sensor
- Differential Global Positioning System (DGPS) receiver and antenna
- Console display microprocessor and PCMCIA card
- Software that is loaded on a desktop computer to create maps

Most yield monitors installed on combines use an impact plate and mass flow sensor located atop the clean grain elevator of the combine to estimate grain flow. As grain leaves the clean grain elevator, it strikes the impact plate. A mass flow sensor at the sensor plate develops an electronic signal that is proportional to the mass of grain hitting the plate (**Figure 1**). This signal, combined with a calibration equation and moisture content, is used to estimate instantaneous grain flow mass.

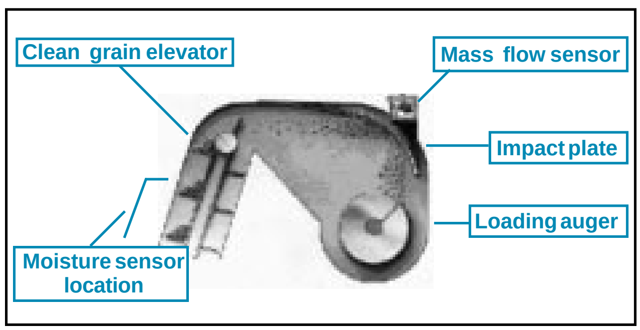

Figure 1. A schematic diagram of the clean grain elevator, impact plate, mass flow sensor, moisture sensor location, and loading auger.

The moisture sensor for most yield monitors is located near the clean grain elevator or fountain auger system. It

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uses chamber-type sensors or a blade inserted into the stream of grain flow to measure capacitance of the grain. Capacitance is directly related to grain moisture content.

Depending on the yield monitoring system, vehicle speed may be determined from add-on radar, add-on wheel speed sensors, DGPS, or pre-existing combine speed sensors. Wheel slippage will not influence accuracy for systems that use DGPS or radar to determine speed.

The yield monitor is normally connected to a DGPS receiver using a RS232 serial communications link. A second cable connects the DGPS receiver to the DGPS antenna which is usually located on the cab roof. The DGPS receiver uses a standard message format, the NMEA 183 GPS-GGA message, to convey latitude and longitude coordinate information to the yield monitor.

The console microprocessor that receives the DGPS latitude and longitude data, flow data, vehicle speed, and moisture data is located in the cab. The monitor calculates the current yield and writes the data to a file on the PCMCIA card. The PCMCIA card can be removed from the yield monitor and inserted into a drive on a desktop computer to download the information.

Yield mapping software can access the yield data stored on the computer from the PCMCIA card, and maps of the measured variables can be created.

Calibration

Each of the sensors required for yield estimation must be correctly calibrated for the system to provide accurate results. A calibration determines the relationship between a sensor output, such as a voltage for the flow sensor or frequency for a radar ground speed sensor, and the measured variable such as grain mass flow rate or vehicle speed. Some sensors are factory calibrated and will require little attention, although it is wise to verify their accuracy occasionally with a test.

The system sensors that should be calibrated or periodically checked include:

- Mass flow sensor
- Moisture sensor
- Grain temperature sensor
- Ground speed sensor

Flow sensor calibration

The flow sensor is calibrated when weighed load totals are input into the console. The flow sensor needs to be calibrated on a regular basis. As a rule of thumb, accuracy is directly related to effort. The flow sensor's factory calibration constants may not be valid for the range of conditions that the operator will encounter. Therefore, it is essential that the operator conduct calibrations.

When the monitor console conducts a calibration, it actually fits an equation of a line that relates the flow sensor signal to a flow rate of grain. If this equation is correct, then the microprocessor does a good job of predicting the accumulated grain in the tank and the instantaneous flow rate as well. To determine the equation of the curved line, the microprocessor must have a series of points that lie along the line. Theoretically, each load total represents one point on that line. The more points that are spread out along the line, the better the processor is able to figure out the equation that best describes those points. To get this wide range of points, it is necessary to harvest loads with high flow rates and loads gathered at low flow rates. If all the calibration loads use nearly the same grain flow rate (same speed and constant yield), then the points given to the microprocessor will all be clustered together. The microprocessor may do a poor job of figuring out the true relationship between the signal and flow. It will also do a poor job of measuring flows that are higher or lower than those which provided calibration loads. Also, if large variation in the flow rates occurs while the calibration loads are collected, the microprocessor is given a calibration point that is sort of an 'average' and does not lie on the line that represents the true signal-to-flow relationship. Since the microprocessor does not know this, it dutifully uses the value given and develops a poor calibration curve.

These issues give rise to some rules that will help to obtain good calibrations:

1. **Calibration loads should weigh between 5,000 and 16,000 lb.** Large loads tend to average out the wide swings in flow rate that occur at the beginning of a pass as the crop is entered and the flow rate ramps up from zero. Hence, for calibration loads, bigger is probably better.
2. **Keep speed constant for each load.** This helps to assure that the signal point on the calibration curve for this load results from a single flow rate past the sensor and not an average flow.
3. **Perform the calibration on a field area that has uniform yield.** This is also an important step in providing the flow sensor with a constant flow rate for the calibration load.
4. **Harvesting less than a full header width can develop low flow rates for the calibration curve.** Don't forget to input how many rows are being harvested into the monitor when harvesting less than a full header width.
5. **Low flow rates for the calibration curve can also be generated by slowing combine speed**.

In addition to load size, speed, and area, other calibration fundamental items need to be considered:

- The scale weighing the calibration load must be accurate.
- The combine grain tank must be empty before starting a calibration.
- The weigh wagon or truck the combine dumps into must also be empty.

Moisture sensor calibration

Final yield (bu/acre) must be adjusted by considering the moisture content of the crop and the corresponding amount of shrinkage. Shrinkage is a function of moisture content. To obtain accurate results, the moisture sensor must be performing properly. Several things need to be considered when calibrating chamber type moisture sensors:

- The yield monitor's moisture sensor should be calibrated with an accurate portable or laboratory moisture tester.
- The moisture sensor chamber or blade should be periodically inspected for build-up of soil and crop material.
- Chamber type moisture sensors should be adjusted so they are full when readings are made to ensure accuracy.

Grain temperature sensor calibration

The grain temperature sensor that modifies the moisture sensor's calibration should be checked. Temperature calibration should be conducted after the temperature is stable, not when the machine is cold.

Ground speed sensor calibration

Ground speed will generally be a relatively trouble free sensor. The sensors used to measure speed are not subject to drift or changes due to conditions the way the flow rate and moisture sensors are. However, it is necessary to assure that the sensor is working. Systems that use a non-driven wheel and a rotational speed detector require that the radius or circumference of the wheel be known by the monitor. The calibration can change if the wheels are changed, damaged or modified. Doppler radars assume a fixed orientation to the ground, and that orientation must be maintained for good results. The DGPS system can also give good estimates of ground speed, and as long as the receiver and the satellite constellation are both working, the speed estimate will be reliable.

A simple test of the ground speed sensor can be conducted by accurately marking a known distance, such as a quarter mile of road. The combine can be driven at a constant speed through this known distance and the time taken from start to finish used to calculate the actual ground speed. The distance in the feet traveled divided by the time in seconds to cover the distance, divided by 1.4666, will yield the speed in mph. If this number does not closely reflect the ground speed indicated by the monitor during the test, the sensor should be checked and serviced. Another alternative is to compare indicated speeds from a Doppler radar sensor or non-driven wheel with the speed measurement from the DGPS measurement. These should be in close agreement.

DGPS

Accurate coordinates are needed for each of the individual yield estimates used to derive yield maps. Fortunately, precise longitude and latitude are routinely provided today by the DGPS system. While this system generally operates quietly in the background, there are a few steps that can be taken to minimize problems associated with the DGPS system.

- Always position the antenna on top of the cab as close to the center of the header as possible (the antenna may be offset from the cab center because some combines do not have symmetrical heads).
- Ensure that all cable connections are secure.
- Use cables as specified by the manufacturer to connect the DGPS receiver to the yield monitor.
- Make sure that the DGPS is receiving differential correction. A more complete discussion of differential GPS may be found in Pfost et al., (1999).

Operator

Do not forget the importance of the operator! The operator needs to make sure the proper crop is selected at harvest, as each crop has its own unique internal calibration curve. It is important to use the proper crop test weight. This is especially important for yield monitors that measure grain by volume rather than by weight (mass). The operator must also input information vital for correct area determination, such as the header width or rows and row spacing. Before harvest, the operator must remove any previous data from the PC card (either SCRAM or ATA FLASH). Pre-harvest information must be entered or corrected on the PCMCIA card. The pre-harvest data may be entered on the PC card via the desktop computer or the yield monitor. How the data is entered on the PC card will depend on the manufacturer. Examples of pre-harvest information include:

- Header type (row crop, platform, pickup head which should be the actual swath width).
- Number of rows.
- Row width or cutting width (cutting width for straight or platform type heads must have the actual cutting width inputted and not the head width; i.e. a 25 ft. straight head may have an actual cutting width of 23.5 ft.). Keep cutting width constant, especially towards twilight when visibility is reduced. If cutting width is inaccurate, yield data will be inaccurate.

Mechanical operations of the combine influence yield monitor performance. The clean grain elevator chain for nearly all systems is the mechanism that delivers grain to the sensor. Therefore, chain tension, elevator speed, and paddle conditions must be inspected and adjusted to ensure correct yield information. The tension on the chain affects the way the paddles throw the grain on the sensor; therefore, if adjusted, the flow sensor may require re-calibration. This is particularly true if the tension adjustment is on the top of the elevator. Mechanical problems at the impact plate can also cause inaccuracies. Some problems to watch for include:

- Impact plate wear.
- Material buildup on the flow and/or moisture sensor. Be especially observant when harvesting sunflowers, soybeans, and other edible beans as crop oil and dirt can adhere to the plate. Other materials that can build up on the flow sensor include green weeds or juice from plants that have berries, such as nightshade.

- Obstructions such as corn stalks can build up or wedge on the sensor.
- The clearance between the tip of the clean grain elevator paddles and the housing should be as close as possible. Systems will vary with respect to the clearance between the paddles and the housing. Follow manufacturer suggested guidelines for installation.

Yield Mapping Software

Software selection and use are the final pieces of the puzzle for yield mapping systems. It is necessary that the operator spend time on the computer, becoming familiar with this software before heading to the field. For example, if split planter trials will be used to evaluate different crop varieties, the operator may want to work with a practice data set prior to harvesting to ensure proper data organization (Doerge and Gardner, 1999). The following items should be completed before heading to the field:

- Enter all farm and field names, varieties, and flags.
- Make certain last yield data has been downloaded and then re-format the data storage card.

Depending on the software, post calibration of the yield data may be possible to further improve yield accuracy. With some yield mapping software, increasing or decreasing the yield or moisture data by a given percent is possible. Also, the yield data may be recalibrated by a specific weight. For example, say a field was harvested and the weigh scale tickets from the entire field indicated that 152,000 lb were harvested, but the yield monitor read 150,000 lb. Yield data from the whole field may be recalibrated through the software using the scale weight of 152,000 lb.

Trouble-shooting Yield Monitor Systems

Information on trouble-shooting yield monitor systems will be available in a subsequent guideline. ■

Improvement and Technical Support for Yield Monitor Systems

AFS (Case IH): 1-888-227-3237 www.caseih.com

Ag Leader: (515) 232-5363 www.agleader.com

Caterpillar: www.cat.com

FieldStar (AGCO): 1-800-201-9618 www.fieldstar.com

Grain-Trak (Micro-Trak): 1-800-328-9613 www.micro-trak.com

GreenStar (John Deere): 1-888-GRN-STAR www.deere.com

For those with John Deere yield mapping systems: www.StellarSupport.com

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