Ag Leader Technology
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Grain Cart Weighing Errors

Introduction

Grain carts with built-in scales have become common, and provide a convenient tool for weighing calibration loads. Grain cart scales use load cells, weigh bars, or weigh axles to sense load weight. These scales perform accurately when evaluated as individual components. Typically, a weight measured with a single weigh bar is expected to be within ±0.25% of its actual value, and a weight measured with a multiple weigh bar system is expected to be within ±1%. Grain carts in the field are sometimes loaded or calibrated in less than ideal ways and resulting errors are larger than scale manufacturer specifications.

Grain Cart Weighing Errors

This article treats grain cart scales as a weighing system, describes sources of grain cart weighing errors, and offers guidelines designed to achieve best results. The six sources of error are described are below.

- Grain Cart Calibration Error
- Weigh-in Motion Error
- Nonlinearity Error
- Off-Center Loading Error
- Ground Slope Error
- Random Error

Grain Cart Calibration Error

Grain carts with scales require calibration to be accurate. Grain cart scales may have never been calibrated or calibrated using an inaccurate or non-certified scale. Fortunately, this can be corrected by following a straight-forward recalibration procedure, usually specified in the grain cart scale's user manual. A test Ag Leader conducted in 2014 found that a new grain cart with only a factory calibration exhibited an error of 1.3%. With proper calibration the calibration error was fixed. Calibrating the grain cart should not be confused with re-zeroing the grain cart scale.

Weigh-In-Motion Error

Weigh-in-motion error refers to errors caused by measuring weight or loading grain cart while in motion. Grain carts produce best results when loaded and weighed when stationary. Excessive error may result when attempting to measure calibration loads while unloading-on-the-go. There will be uncertainty relating the beginning and end of the calibration load to the grain that is unloaded into the cart. Typical errors introduced when unloading-on-the-go are in the 1% range. Additionally, when the grain cart moves after a re-zeroing weight before filling with the calibration load, additional random error is introduced.

Nonlinearity Error

Common grain cart scales use linear calibration curves; however some nonlinearity is often present. Nonlinearity errors vary with the total amount of grain in the cart. As the amount of grain in the cart increases from empty to full, nonlinearity error percentage changes in size, and sometimes greater than or less than the actual load size.

Nonlinearity errors cannot be calibrated out using a linear calibration function, but the effect can be minimized. If the grain cart is calibrated using the same sized load as is used for weighing harvest calibration loads, then nonlinearity error will not be present.

A typical case of nonlinearity error is illustrated in Figure 1. In this case, the grain cart scale was calibrated with a full load, and a nonlinearity error of -1.5% was present when measuring weight for a one combine grain tank calibration load. As shown in Figure 2, when the grain cart scale was calibrated with a one combine grain tank load, nonlinearity error was eliminated for that load size.

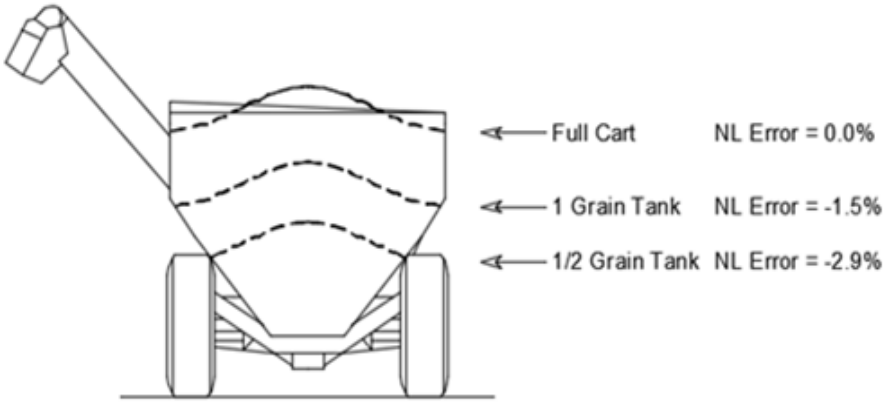

Figure 1- Nonlinear error based on calibrating grain cart using full grain cart.

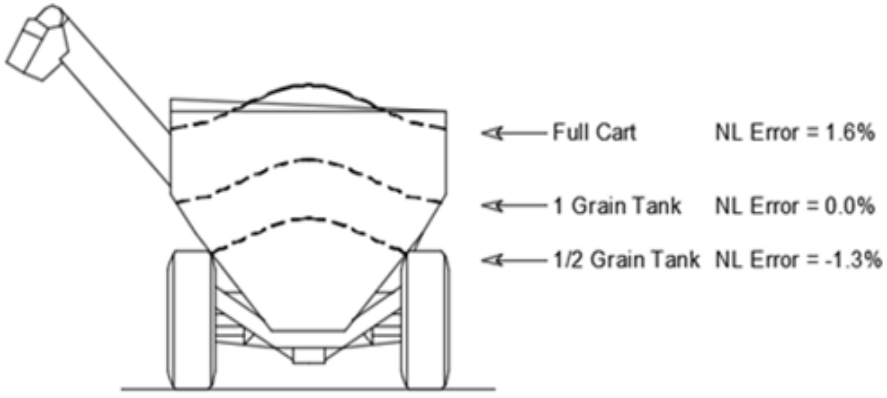

Figure 2- Nonlinear error based on calibrating grain cart using one combine grain tank.

Off-Center Loading Error

Some grain cart scale designs are susceptible to errors induced when the cart is not loaded evenly from the center. This effect increases error when an asymmetric pile develops in the cart as shown in Figure 3. In the instance illustrated, even though the scaled cart was correctly calibrated, when the pile was concentrated in the front of the cart, off-center loading error was -1.6% of a combine grain tank load. Figure 4 shows an ideal grain cart fill for minimizing off-center loading errors.

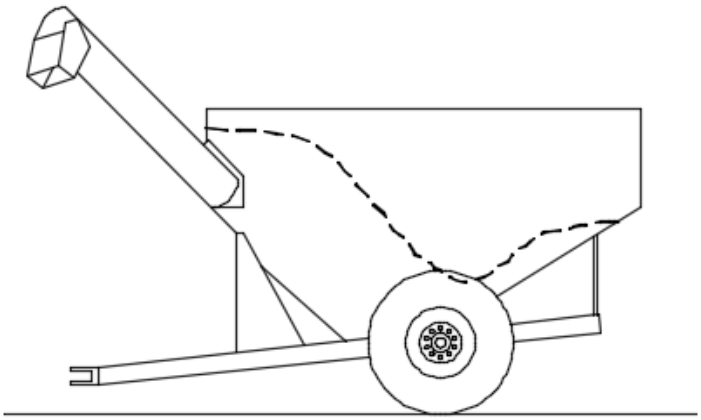

Figure 3- Grain cart that was loaded off center.

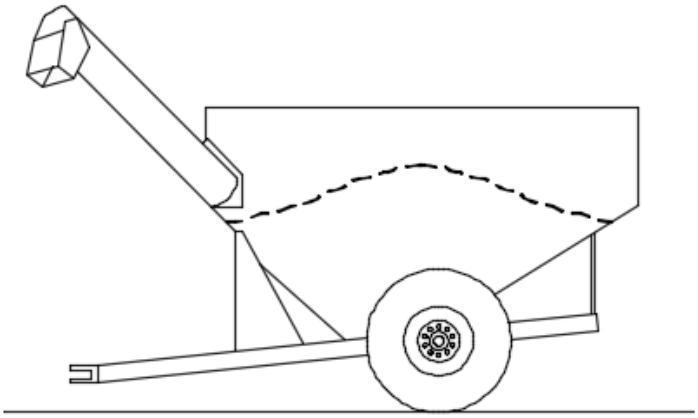

Figure 4- Ideal grain cart fill.

Ground Slope Error

Positioning a grain cart with scales on ground that is not level can introduce errors. Typical errors from 7% slope are in the 0.8% range. Figure 5 illustrates the effect.

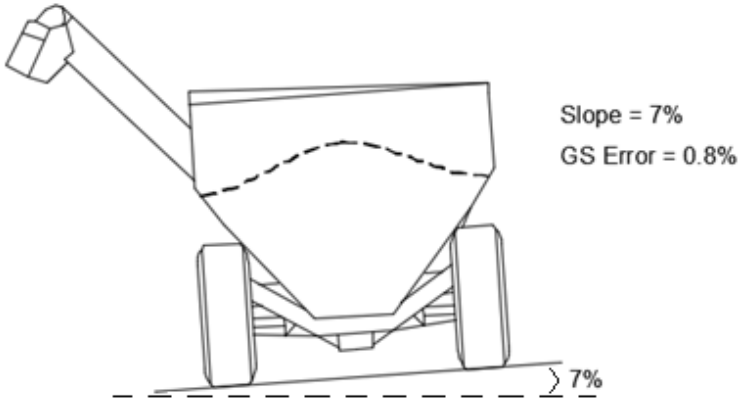

Figure 5- Error cause by grain cart on uneven ground.

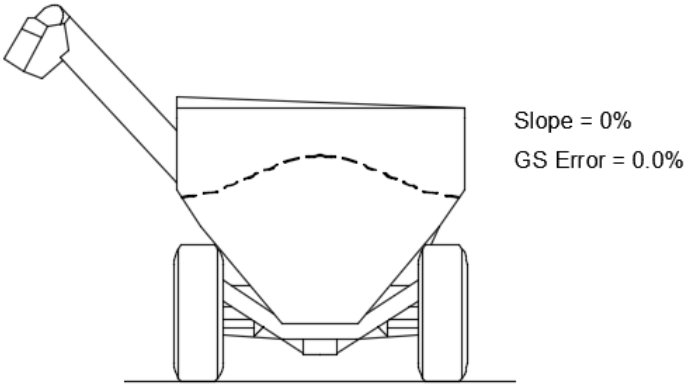

Figure 6- Grain cart on level ground without error.

Random Error

Random Error includes all errors that appear to be random, and cannot easily be attributed to a specific source. Random errors can be evaluated by making repeated measurements under constant test conditions, then evaluating variation in the results. Random errors evaluated this way are sometimes referred to as non-repeatability errors. Random error is unavoidable, and cannot be calibrated out. Testing conducted by Ag Leader in 2014 and 2016 Harvest seasons showed calibration loads may have random error of up to 1.2%.

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Grain Cart Usage Guidelines

1. Calibration load size: 1 full combine grain tank.
2. Use consistent load size for all calibration loads.
3. Grain cart scale must be calibrated. Ideally calibration is/was completed using one full combine grain tank worth of grain. Recalibrating a grain cart is not the same as taring, or zeroing the scale. Follow calibration procedure within grain cart scale user manual.
4. Before starting a calibration load, make sure the combine and grain cart have harvested and dumped at least 10-20 bushels of grain to prime the augers .
5. Always start calibration load with an empty combine and weigh device.
6. Only unload into a grain cart sitting still and weigh calibration load before grain cart is moved to dump.
7. Unload into the grain cart when on level ground. Ideally slope should be less than 3.5%.
8. Unload directly into the center of the grain cart to achieve symmetrical loading.

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