ACCURACY AND PRECISION OF THE FIRE® PERFORMANCE TESTING FEEDER

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1. BASIC FEED MEASUREMENT FOR PERFORMANCE TESTING

The Osborne FIRE® Performance Testing Feeder was developed to automate performance testing while permitting group feeding of pigs. The alternative and traditional method of performance testing is to feed individuals or sibling pairs in socially isolated pens in order to measure the feed disappearance for each animal. Feed disappearance is equated to feed intake after correction for estimated feed wastage.

The FIRE System attempts to achieve the same objective, but without social isolation of the pigs. To accomplish this objective, feed disappearance for each pig is determined by weighing a feed trough before and after each feeding event. The weight difference is the weight of feed disappearance for that event and is recorded to the event record for the pig identified in the feeder during the feeding event. All such event records are automatically accumulated in a database for later analysis.

As the feed disappears from the FIRE feed trough, the trough must be periodically refilled or "topped-up". This top-up can occur either while an animal is absent or while an animal is eating. If a top-up occurs while an animal is absent, then the amount added to the trough is directly weighed and the starting weight of the trough is adjusted automatically. If a top-up occurs while an animal is eating, then the amount of feed added to the trough is computed based on the volume of the delivery and a volume-to-weight ratio called the Dynamic Portion Calibration (DPC) factor because a direct weigh is not reliable owing to animal activity in the trough. The DPC factor is computed from top-ups using direct weighing when an animal is not present. The DPC factor is continuously and automatically adjusted as the density or moisture content affects the volume-to-weight ratio to maintain the best accuracy of feed measurements without interfering with the feeding activity of the pigs.

2. ACCURACY AND PRECISION OF FEED MEASUREMENT

2.1 ACCURACY AND PRECISION OF FEED WEIGHTS

An estimate of the accuracy and precision of automated feed delivery is important for comparison to alternative testing methods and for an understanding of the confidence limits on the performance characteristics of the animals under test.

In the laboratory, a good estimate of the accuracy of the FIRE equipment can be measured by simulating animal eating and top-ups. To test accuracy a series of feed disappearance events (meals) were collected and weighed using a calibrated scale to establish the actual weight. These values were compared with the weights reported for the same pseudo-meal by the FIRE feeder weighing system.

FIRE feed weights were **within 1.0% of the actual weight, based on a 99.5%** confidence interval and **within 0.25% of that actual weight at a 95%** confidence level. A one-sided t-test was used to estimate the distribution of weight measures about the actual weight as determined by the calibrated scale.

For a measure of precision of the FIRE weight measurement, the weight of a fixed weight with an accurately known calibration weight was repeatedly measured over an extended period in multiple FIRE feeders while in service. The standard deviation divided by the average value for each series of calibration tests ranged from **0.5 to 2.0% with an average precision of 1.5%** in all tests, suggesting that precision of the FIRE measurement was sufficient to deliver the measured accuracy of the estimate of feed disappearance in practice.

2.2 ACCURACY OF FEED DELIVERY

The other part of FIRE feeder accuracy is the amount of feed dispensed during a top-up. When a top-up occurs in the absence of an animal, then this accuracy is essentially the same as the weighing accuracy discussed in 2.1 above, subject to considerations in 2.3 following. When a top-up occurs in the presence of an animal, beginning and ending weights are not available. The accuracy then depends on the accuracy of the DPC factor.

The accuracy of the DPC factor can be tested in the laboratory by generating top-up events, recording the top-up amount measured by the FIRE scale using the automatically computed value of the DPC, and then comparing these values with the actual weight of delivered feed as measured by a calibrated scale. The accuracy of top-up using the DPC value was found to be within **1% with a 99.5%** confidence interval and within **0.5% with a 95%** confidence interval, using the one-sided t-test. Delivery accuracy was consistent with the accuracy of feed weighing.

2.3 ACCURACY UNDER FIELD CONDITIONS

Laboratory measures of accuracy are made under ideal conditions, i.e., solid cement floor, low electrical noise, and no vibrations by animal activity. Production environments are not as favorable for making accurate and precise measurements.

Under production conditions, estimates of accuracy and precision are not easily separated and both will be strongly dependent upon the particular environment of use. The following describes such measures of accuracy for environmental conditions of use on the Osborne Demonstration Farm, but actual accuracy for any system must be determined for local conditions by each user. A discussion of the effect of various parameters and conditions on overall system accuracy is also given. In general, the overall accuracy of FIRE feed performance measurements in these tests has been **in the range of 0.5 to 2.5%** with an **average accuracy of about 1.5%** for all tests and for all feeders under the conditions of these measurements.

2.3.1 The DPC factor

Accuracy in production is mainly dependent upon the accuracy of the Dynamic Portion Calibration (DPC) factor, all other sources of error begin suitably small. The accuracy of this factor alone is in the range of 2 to 4%, but when combined with direct weight measurements which inherently have an accuracy of about 1%, the overall accuracy range of 0.5 to 2.5% is established. This accuracy range is established by dependence of the DPC factor upon the following considerations:

a.) Frequency of DPC up-date. The DPC is automatically redetermined at each top-up without an animal present. For about 15 animals, such “clean” top-ups and DPC recalculation occurs for about 5% of all top-ups. This frequency is dependent upon the frequency of meals and pauses between meals. The frequency of meals increases for larger numbers of animals, for smaller animals which eat more, smaller meals than larger animals, and for certain types of feeds because meal feed encourages more meals than pelleted feed. Accuracy is therefore improved by limiting the number of animals on test, by testing larger animals, and by using pelleted feed.

b.) Additional operating complications. Other factors can reduce accuracy during the time between measured top-ups with DPC recalculation. For example, meal feed can change density owing to vibrational packing or feed addition to the hopper. Feed density can change rapidly owing to moisture absorption by the dry meal feed in the hopper. We have measured changes of 1 to 2% with dry meal. Based on our tests, accumulated average DPC errors at each successful top-up are in the range of 2 to 4%, but only 20 to 50% of all measured meals require the use of the DPC value. Based on this frequency and the accuracy of directly measured meals, overall individual meal accuracy is between 0.5 and 2.5% if environmental and usage error conditions are controlled within a reasonable and recommended range.

2.3.2 What does this accuracy mean?

An accuracy of 0.5 to 2.5% must be understood within the context of this type of measurement. This percentage is an accuracy estimate for *each individual meal* for group housed pigs. A better estimate is developed by measuring and averaging the results from about 10 to about 30 meals per day per pig. Assuming a normal distribution of all sources of error, then the expected daily intake measurement error is reduced by the square root of the number of meals measured. The average number of meals per pig ranges from 10 to 30, suggesting a three to six-fold reduction in estimated error. A better estimate of overall accuracy for the daily measurement then ranges from 0.17 to 0.63%. For an animal consuming 4 kg per day, this means a worst-case error of 0.0063 x 4000 = 25 grams of feed. Notice that this measurement error is in the range of actual feed wastage from the trough which can range up to 1 to 2%, again depending upon the number of animals and the type of feed.

For comparison in manual feed testing, an animal eating 4 kg of feed a day with a worst-case of 2.5% error for a single feed measurement, the weight measurement of an individual meal must be within 0.025 x 4000 = 100 grams to match the accuracy of FIRE. Such accuracy would require a scale accuracy of about 10 grams to accomplish and, in practice, such a scale is rarely available for manual performance testing.

Additive accumulated errors from changing feed moisture content, accuracy of daily collection and weighing back left-over feed, and animal feed spillage can cause total error to range upwards to 5% or more, depending on the method of feeding and the feed fed. A full accounting of manual errors can quickly dwarf the measured operating errors for a properly operated and maintained FIRE system.

Finally, the largest source of performance measurement error is the difference between feed intake and utilization that has been well documented between individual and group-fed and housed animals. Individually penned animals have different thermal requirements, different feeding habits, and a host of other differences that directly and indirectly affect feed intake and feed conversion. For example, individually penned animals have higher daily feed intakes (Gonyou et al., 1992, Appl. Animal Behav. Sci. 34:291-301), higher growth rates, (DeHaer and De Vries, 1993, Livest. Prod. Sci., 33: 277-292), and better feed conversions (Petersen, 1976, Zütungskunde, 48:56-65) compared to group-penned animals. In comparison, swine provided adequate space (including area, feed access, and water access) have similar performance when penned in groups of up to 50 pigs. Clearly, performance studies must use group penned animals to acquire measurements that are relevant to commercial production in preference to measurements obtained from individually penned animals. The Osborne FIRE system provides the accuracy required to develop individual data on group-housed animals.

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