Field Calibration Procedures
for Animal Wastewater Application Equipment

HARD HOSE AND CABLE TOW TRAVELER IRRIGATION SYSTEM

North Carolina Cooperative Extension Service

North Carolina State University

HARD HOSE AND CABLE TOW TRAVELER IRRIGATION SYSTEM

Land application equipment used on animal production farms must be field calibrated or evaluated in accordance with existing design charts and tables according to state rules that went into effect September 1, 1996. Technical Specialist certifying waste management plans after September 1, 1996, must also certify that operators have been provided calibration and adjustment guidance for all land application equipment. The rules apply to irrigation systems as well as all other types of liquid, slurry, or solid application equipment.

Information presented in manufacturers' charts are based on average operating conditions for relatively new equipment. Discharge rates and application rates change over time as equipment ages and components wear. As a result, equipment should be field calibrated regularly to ensure that application rates and uniformity are consistent with values used during the system design and given in manufacturers' specifications. Field calibration involves collection and measurement of the material being applied at several locations in the application area. This publication contains step-by-step guidelines for field calibration of hard hose and cable tow traveler irrigation systems.

General Guidelines

Operating an irrigation system differently than assumed in the design will alter the application rate, uniformity of coverage, and subsequently the application uniformity. Operating with excessive pressure results in smaller droplets, greater potential for drift, and accelerates wear of the sprinkler nozzle. Pump wear tends to reduce operating pressure and flow. With continued use, nozzle wear results in an increase in the nozzle opening, which will increase the discharge rate while decreasing the wetted diameter. Clogging of nozzles or crystallization of main lines can result in increased pump pressure but reduced flow at the gun. Plugged intakes will reduce operating pressure. An operating pressure below design pressure greatly reduces the coverage diameter and application uniformity. Field calibration helps ensure that nutrients from animal waste are applied uniformly and at proper rates.

The calibration of a hard hose or cable tow system involves setting out collection containers, operating the system, measuring the amount of wastewater collected in each container, and then computing the average application volume and application uniformity.

An in-line flow meter installed in the main irrigation line provides a good estimate of the total volume pumped from the lagoon during each irrigation cycle. The average application depth can be determined by dividing the pumped volume by the application area. The average application depth is computed from the formula:

$$\text{Average application depth (inches)} = \frac{\text{Volume pumped (gallons)}}{\text{27,154 (gal/ac-in) X Application area (acres)}}$$

The average application depth is the average amount applied throughout the field. Unfortunately, sprinklers do not apply the same depth of water throughout their wetted diameter. Under normal operating conditions, application depth decreases towards the outer perimeter of the wetted diameter. Big gun sprinkler systems typically have overlap based on a design sprinkler spacing of 70 to 80 percent of the wetted sprinkler diameter to compensate for the declining application along the outer perimeter. When operated at the design pressure, this overlap results in acceptable application uniformity.

When operated improperly, well-designed systems will not provide acceptable application uniformity. For example, if the pressure is too low, the application depth will be several times higher near the center of sprinkler and water will not be thrown as far from the sprinkler as indicated in manufacturers' charts. Even through the average application depth may be acceptable, some areas receive excessively high application while others receive no application at all.

When applying wastewater high in nutrients, it is important to determine the application uniformity. Collection containers distributed throughout the application area must be used to evaluate application uniformity.

Many types of containers can be used to collect flow and determine the application uniformity. Standard rain gauges work best and are recommended because they already have a graduated scale from which to read the application depth.

Pans, plastic buckets, jars, or anything with a uniform opening and cross section can be used provided the container is deep enough (at least 4 inches deep) to prevent splash and excessive evaporation, and the liquid collected can be easily transferred to a scaled container for measuring. All containers should be the same size and shape to simplify application depth computations.

All collection containers should be set up at the same height relative to the height of the sprinkler nozzle (discharge elevation). Normally, the top of each container should be no more than 36 inches above the ground. Collectors should be located so that there is no interference from the crop. The crop canopy should be trimmed to preclude interference or splash into the collection container.

Calibration should be performed during periods of low evaporation. Best times are before 10 a.m. or after 4 p.m. on days with light wind (less than 5 miles per hour). On cool, cloudy days the calibration can be performed anytime when wind velocity is less than 5 mph.

The volume (depth) collected during calibration should be read soon after the sprinkler gun cart has moved one wetted radius past the collection gauges to minimize evaporation from the rain gauge. Where a procedure must be performed more than once, containers should be read and values recorded immediately after each setup.

Calibration Setup for Hard Hose and Cable Tow Traveling Guns

Hard hose and cable tow traveling guns are calibrated by placing a row (transect) of collection containers or gauges perpendicular to the direction of travel, Figure 1. The outer gauge on each end of the row should extend past the furthest distance the gun will throw wastewater to ensure that the calibration is performed on the "full" wetted diameter of the gun sprinkler. Multiple rows increase the accuracy of the calibration.

Containers should be spaced no further apart than 1/16 of the wetted diameter of the gun sprinkler not to exceed 25 feet. At least 16 gauges should be used in the calibration. Sixteen gauges will be adequate except for large guns where the wetted diameter exceeds 400 feet.

(Maximum recommended spacing between gauges, 25 feet X 16 = 400 feet.) Gauges should be set at least one full wetted diameter of throw from either end of the travel lane, as shown in Figure 1.

The system should be operated such that the minimum travel distance of the gun cart exceeds the wetted diameter of throw. Application volumes should be read as soon as the last gauges stop being wetted.

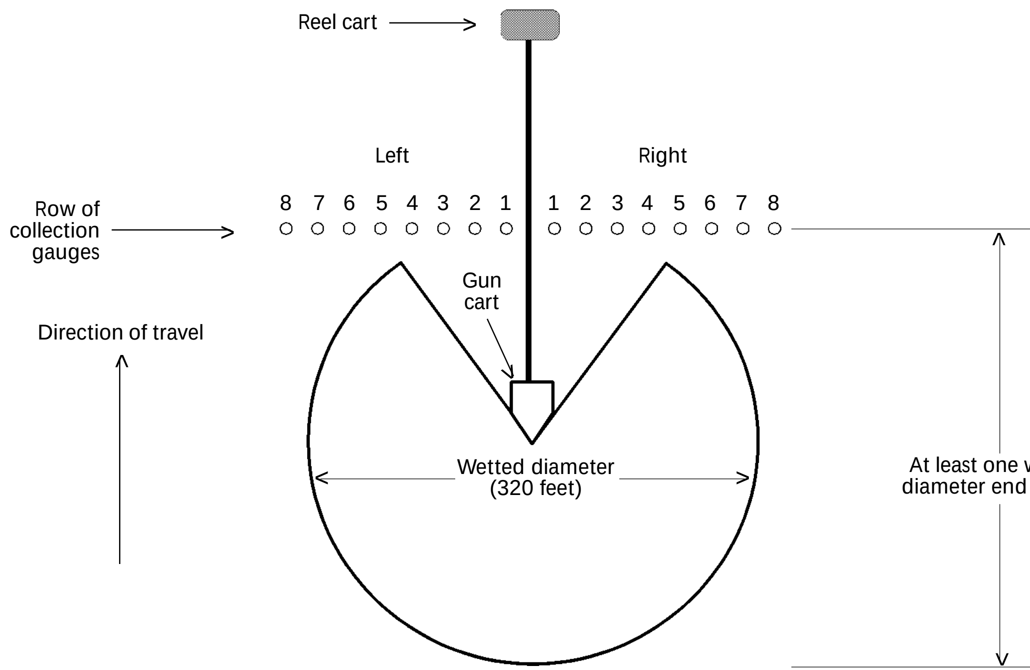


Figure 1. General layout and orientation of collection gauges for calibration of a hard hose and cable tow traveler irrigation systems.

CALIBRATION PROCEDURES

1. Determine the wetted diameter of the gun.
2. Determine the number of collection gauges and spacing between gauges. For a wetted diameter of 320 feet, the rain gauge spacing should not exceed 20 feet. (320 ft / 16 = 20 ft).
3. Label gauges outward from the gun cart as either left or right (L1, L2, L3, etc; R1, R2, R3, etc.)
4. Set out gauges along a row as labeled and shown in Figure 1, equally spaced at the distance determined in item 2 (20 feet). The row should be at least one wetted diameter from either end of the pull. The first gauge on each side of the travel lane should be 1/2 the gauge spacing from the center of the lane. For a gauge spacing of 20 feet, L1 and R1 should be 10 feet from the center of the lane.
5. Operate the system for the time required for the gun to completely pass all collection containers. Record the "starting" time that wastewater begins to be applied along the row of gauges and the "ending" time when wastewater no longer is being applied anywhere along the row. Also record the distance traveled in feet for the time of operation.
6. Immediately record the amounts collected in each gauge. (Refer to Table 1 for an example.)
7. Identify those gauges that fall outside the effective lane spacing, Figure 2. This volume is the overlap volume that would be collected when operating the system on the adjacent lane.
8. Superimpose (left to right and vice versa) the gauges just outside the effective width with the gauges just inside the effective width. Add the volumes together.

   For the layout shown in Figure 2, add the volume (depth) collected in gauge R8 (outside the effective lane spacing) to volume (depth) collected in gauge L5 (inside the effective lane spacing). Similarly, R7 is added to L6; L8 is added to R5; and L7 is added to R6. This is now the application volume (depth) within the effective lane spacing adjusted for overlap.

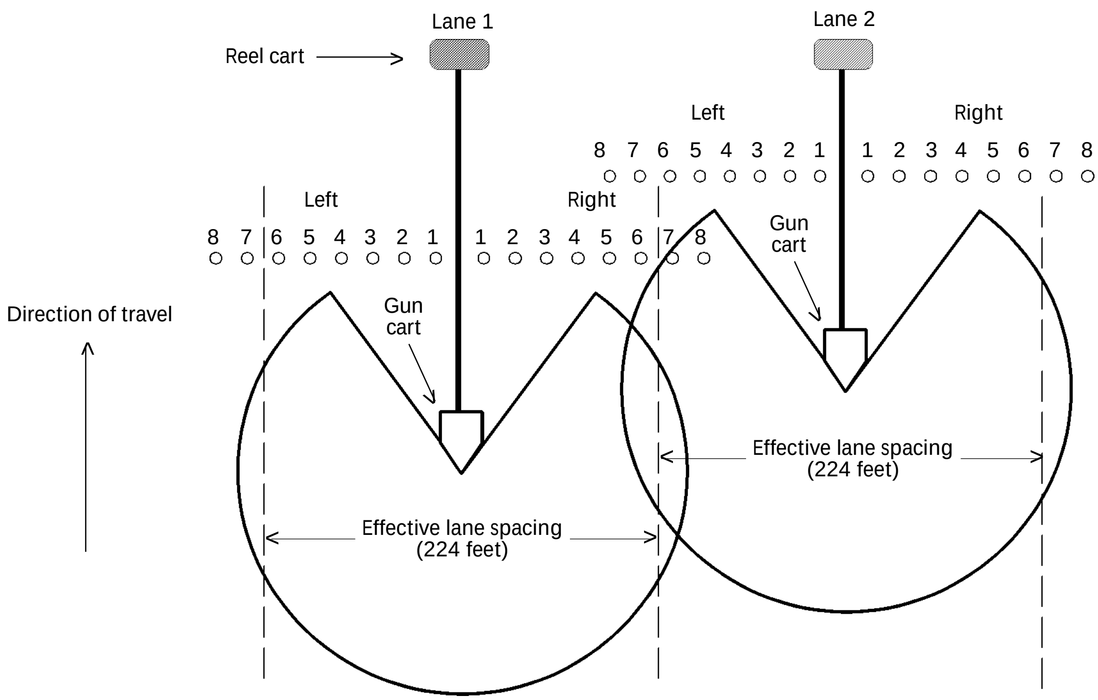


Figure 2. Accounting for overlap when calibrating a hard hose traveler system.

CALIBRATION PROCEDURES (*continued*)

9. Add the amounts collected in all gauges and divide by the number of gauges within the effective area. This is the average application depth (inches) within the effective lane spacing.

$$\text{Average application depth} = \frac{\text{Sum of amounts collected in all gauges}}{\text{Number of gauges within effective width}}$$

10. Calculate the deviation depth for each gauge. The deviation depth is the difference between each individual gauge value and the average value of all gauges (#7). Record the absolute value of each deviation depth. Absolute value means the sign of the number (negative sign) is dropped and all values are treated as positive. The symbol for absolute value is a straight thin line. For example, |2| means treat the number 2 as an absolute value. It does not mean the number 121. Because this symbol can lead to misunderstandings, it is not used with numbers in the worksheets at the end of this publication. The symbol is used in formulas in the text.

$$\text{Deviation depth} = |\text{Depth collected in gauge } i - \text{average application depth}|$$

"i" refers to the gauge number

11. Add amounts in #10 to get "sum of the deviations" from the average depth and divide by the number of gauges to get the average deviation.

$$\text{Average deviation depth} = \frac{\text{Sum of deviations (add amounts computed in \#10)}}{\text{Number of gauges within effective lane spacing}}$$

12. The precipitation rate (inches/hour) is computed by dividing the average application depth (inch) (#9) by the application time (hours) (#5)

$$\text{Precipitation rate} = \frac{\text{Average application depth (inch)}}{\text{Application time (hours)}}$$

CALIBRATION PROCEDURES (*continued*)

13. Compute the average travel speed

$$\text{Average travel speed} = \frac{\text{Distance traveled (feet)}}{\text{Time (minutes)}}$$

14. Determine the application uniformity. The application uniformity is often computed using the mathematical formula referred to as the Christiansen Uniformity Coefficient.

It is computed as follows:

$$U_c = \frac{\text{Average depth (\#9)} - \text{Average deviation (\#11)}}{\text{Average depth (\#9)}} \times 100$$

15. Interpret the calibration results. The higher the index value, the more uniform the application. An index of 100 would mean that the uniformity is perfect — the exact same amount was collected in every gauge.

For travelers with proper overlap and operated in light wind, an application uniformity greater than 85 is common.

Application uniformity between 70 to 85 is in the “good” range and is acceptable for wastewater application.

Generally, an application uniformity below 70 is considered unacceptable for wastewater irrigation using travelers. If the computed Uc is less than 70, system adjustments are required. Contact your irrigation dealer or Certified Technical Specialist for assistance.

Table 1. Example calibration data for a traveling gun system operated in parallel lanes. Lane spacing 70 percent of sprinkler wetted diameter.

a. Manufacturers’ Specifications: Gun Model 150 — Type Taper Bore

Nozzle Dia. 0.9 inch — Pressure (Gun) 70 psi — Reel 105 psi

Wetted diameter 320 ft — Effective Spacing 224 ft — Flow 197 GPM

Hose Size: Length 800 ft — Diameter 3 in

b. Spacing between collection containers (spacing 320 (ft) / 16) = 20 ft

c. Number of gauges = 16

d. Start of Irrigation event 7:15 a.m.

e. End of Irrigation event 9:00 a.m.

f. Duration (e-d) 105 minutes

g. Travel distance 320 feet

h. Operate the system and collect data.

Table 1. Calibration Data (*continued*)

Gauge No.	Distance from Center (feet)	Volume Collected (inches)	Overlap Adjustment (inches)	Corrected Volume (inches)	Deviation from Average* (inches)
L1	10	.94		.94	.235 (1 - j)
L2	30	.80		.80	.095 (2 - j)
L3	50	.59		.59	.115 (etc)
L4	70	.61		.61	.095
L5	90	.50	.13	.63	.075
L6	110	.42	.20	.62	.085
L7	130	.33			
L8	150	.07			
R1	10	.73		.73	.025
R2	30	.81		.81	.105
R3	50	.92		.92	.215
R4	70	.64		.64	.065
R5	90	.50	.07	.57	.135
R6	110	.27	.33	.60	.105
R7	130	.20			
R8	150	.13			

**Absolute value; treat all values as positive.*

i. Sum of all volumes collected in #h 8.46 inches

j. Average catch (i/number of gauges within effective width (12) 0.705 inches

k. Compute the average travel speed = $\frac{\text{Distance traveled (ft)}}{\text{Time (min)}} = \frac{320 \text{ ft}}{105 \text{ min}} = \underline{3.04 \text{ ft/min}}$

l. Precipitation rate = $\frac{\text{average depth (inches)}}{\text{application time (hour)}} = \frac{0.705 \text{ in}}{1.75 \text{ hr}} = \underline{0.40 \text{ in/hr}}$

m. Sum of deviations from the average catch 1.356

n. Average deviation from average catch (m/12) 0.113

o. Uniformity coefficient

$$U_c = \frac{0.705 - 0.113}{0.705} \times 100 = \underline{84}$$

p. Interpret results. Uniformity coefficient of 84 is in the good range for a traveler system. No adjustment is necessary.

Irrigation System Calibration Data Sheet for Hard Hose Traveler Irrigation System

DATE:____________ Land Owner _________________ Farm No. _____________

a. Manufacturers' Specifications: Gun Model __________ Type _________________

Nozzle Dia. __________in Pressure (Gun)__________ (Reel) _________________

Wetted diameter ______ ft Effective Spacing ______ ft Flow ________ GPM

Hose Size: Length ______ft Diameter ____________in

b. Spacing between collection containers (diameter ________(ft) / 16) = _____ft

c.

$$\text{Number of gauges} = \frac{\text{wetted diameter (ft)}}{\text{gauge spacing (ft)}} = \_\_\_\_\_\_\_\_\_\_ = \_\_\_\_\_\_$$

d. Start of Irrigation event

e. End of Irrigation event

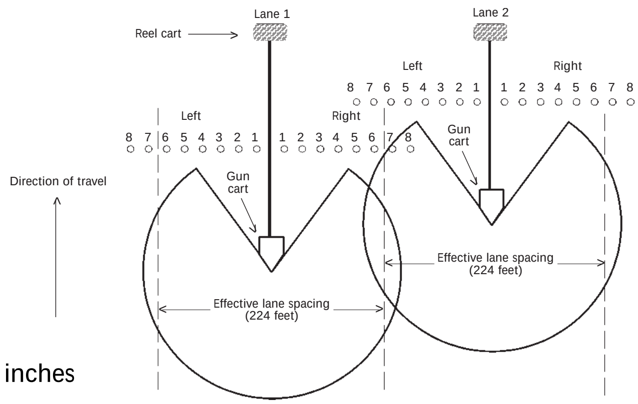
f. Duration (e-d) __________ min

g. Travel distance __________ feet

h. Operate the system, collect data,
and record on the worksheet on page 8.

i. Sum of all catches _______ inches

j. Average catch (i/number of gauges) _______ inches



k.

$$\text{Average travel speed} = \frac{\text{Distance traveled (ft)}}{\text{Time (min)}} = \_\_\_\_\_\_\_\_\_$$

l. Sum of all deviations from the average catch _____

m. Average deviation from average catch _____

n. Uniformity coefficient

$$U_c = \frac{\_\_\_\_\_\,(j) - \_\_\_\_\_\,(m)}{\_\_\_\_\_\_\,(j)} \times 100 = \_\_\_\_\_$$

Interpret the calibration data and make necessary adjustments.

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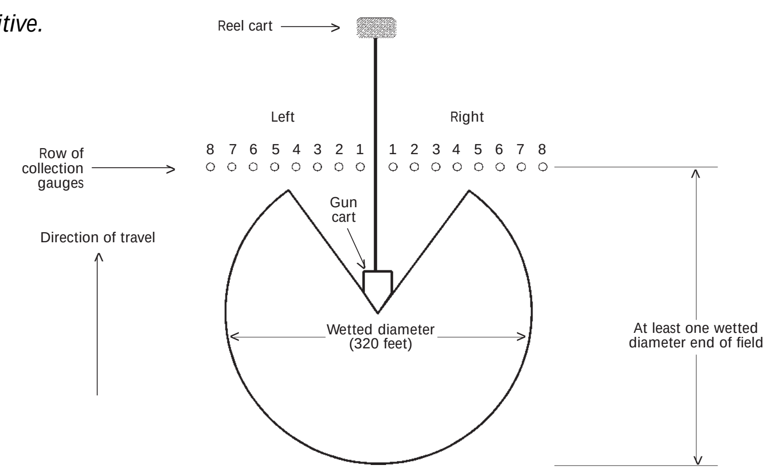
Application uniformity between 70 to 85 is in the "good" range and is acceptable for wastewater application.

Generally, an application uniformity below 70 is considered unacceptable for wastewater irrigation using travelers. If the computed U_c is less than 70, system adjustments are required. Contact your irrigation dealer or Certified Technical Specialist for assistance.

Calibration Data (*continued*)

Gauge No.	Distance from Center (feet)	Volume Collected (inches)	Overlap Adjustment (inches)	Corrected Volume (inches)	Deviation from Average* (inches)
L1	_____	_____	_____	_____	_____
L2	_____	_____	_____	_____	_____
L3	_____	_____	_____	_____	_____
L4	_____	_____	_____	_____	_____
L5	_____	_____	_____	_____	_____
L6	_____	_____	_____	_____	_____
L7	_____	_____	_____	_____	_____
L8	_____	_____	_____	_____	_____
L9	_____	_____	_____	_____	_____
L10	_____	_____	_____	_____	_____
R1	_____	_____	_____	_____	_____
R2	_____	_____	_____	_____	_____
R3	_____	_____	_____	_____	_____
R4	_____	_____	_____	_____	_____
R5	_____	_____	_____	_____	_____
R6	_____	_____	_____	_____	_____
R7	_____	_____	_____	_____	_____
R8	_____	_____	_____	_____	_____
R9	_____	_____	_____	_____	_____
R10	_____	_____	_____	_____	_____

**Absolute value;
treat all values as positive.*



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