Economic Analysis of a Traveling Gun for Feedyard Dust Suppression

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Abstract

Dust created in feedyards can adversely affect cattle performance. Dust suppression can be accomplished by moistening pen surfaces with traveling gun(s) sprinklers, solid-set sprinklers, and water trucks. This study specifically addresses the fixed and operational costs associated with a traveling gun sprinkler system for various sized feedyards.

Key Words: traveling gun, dust suppression, fixed costs, operational costs

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Introduction

Dust control in feedyards can improve air quality and reduce respiratory problems in cattle. According to MacVean et al., "dust can compromise the health of animals by stressing the respiratory system. Pulmonary irritation and resulting edema are thought to facilitate an initial viral infection which could further compromise lung defenses and predispose the lungs to bacterial infection."

Controlling dust in feedyards can be accomplished by moistening pen surfaces with the use of solid-set sprinklers, traveling gun(s) sprinkler system, and/or water truck(s). The objective of this study is to conduct an economic analysis of the traveling gun(s) sprinkler system. The specific objectives are to:

- Conduct a literature review to determine the advantages/disadvantages of alternative forms of dust control.
- Identify the capital investment and operating costs associated with traveling gun(s) sprinkler system.

Background

The low humidity and sunshine that typify weather conditions in confined cattle feeding operations in the Southern Great Plains are conducive for the formation of feedyard dust. Summer conditions are characterized by "…long, warm days, abundant sunshine, persistent winds and generally low to moderate humidity, depending on the position of the dry line, an active boundary separating the Gulf of Mexico influence (southeast winds and higher humidity) from the Mexican plateau influence (southwest winds and lower humidity)" (Auvermann, 2003).

Low humidity, winds, and sunshine, tend to lower the moisture content of manure. Manure dried down to less than 25% moisture creates favorable conditions for the formation of feedyard dust. The cattle themselves serve as the catalyst in creating dust events. Cattle are typically sluggish and rest during the heat of the day. As temperatures decline, cattle activity increases due to feeding, waiting to feed, drinking, standing, walking, and agonistic behavior such as bulling that results in "…the pulverizing and subsequent suspension of accumulated dry, loose manure by hoof action." (Auvermann, 2003). As this loose manure becomes suspended, a dust cloud can form. This dust produces a haze that cattle cannot escape from, thus increasing the possibility of contracting respiratory maladies.

According to Lorimor (2003), the optimum moisture level in an open-lot feedyard is 25% to 40%. At approximately 40% moisture, odor and flies becomes a problem. Dust can be the significant negative health issue at less than 25% moisture, Figure 1.

The principle method to suppress dust in a feedyard is application of sufficient amount of water to maintain the moisture content of manure at above 25% on pen surfaces. The three primary approaches of achieving this are solid-set sprinkler, water truck, and traveling gun(s) sprinkler.

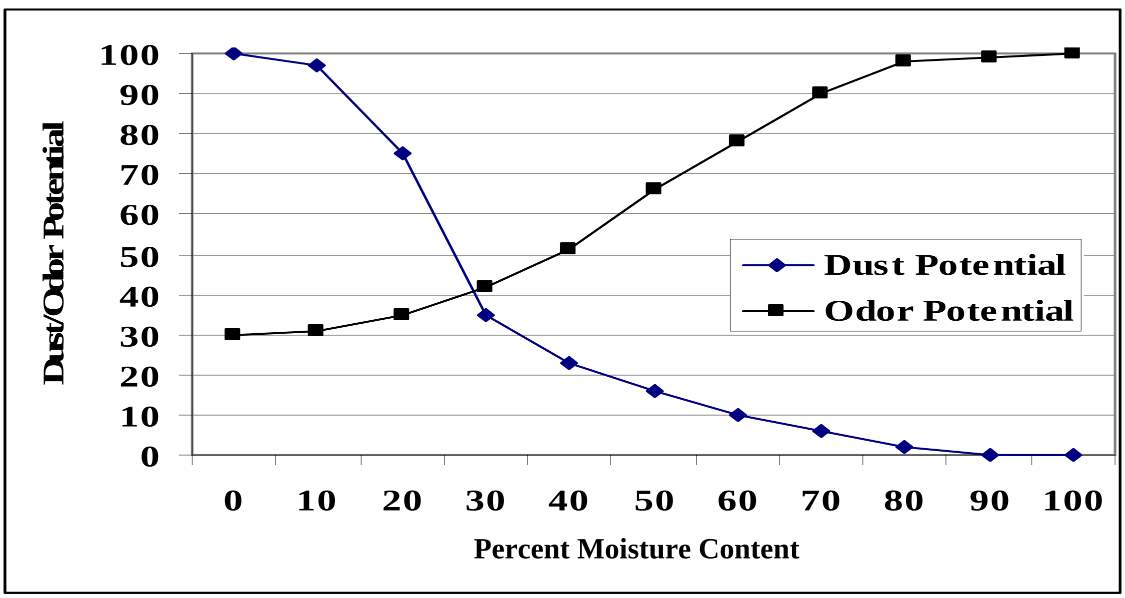

Figure 1. Conceptual, Qualitative Relationship between Dust Potential and Odor Potential as a Function of the Moisture Content of an Open-Lot Surface.
Source: Open Feedlot Construction and Management for Water and Air Quality Protection.

Solid-set sprinklers are stationary water guns mounted in a pen to wet the area without spraying water into the feed bunk. This system has a relatively higher initial investment cost, but is easily automated creating less labor requirements than other water application methods (Guerrero, 2005).

Water trucks are utilized to apply water in the pens and on roads within the feedyard. The water truck requires less initial capital expenditure, but is more labor intensive and requires additional maintenance than solid-set sprinklers (Queensland Government, 2003). Often times, the water truck will “dead head” to refill the truck tank, thus requiring extra time and fuel costs (ACFA and AAFRD, 2002).

A feasibility analysis of applying water to the feedyard pen surface utilizing a traveling gun(s) sprinkler system is the focus of this study. Advantage of this system is lower initial investment compared to solid-set sprinkler. On the other hand, the traveling gun system is labor intensive and may require more management than the water truck or solid-set sprinkler methods.

A traveling gun sprinkler is composed of a hose traveler reel, gun cart, and big gun sprinkler with a nozzle. This is a high capacity, high-pressure, single-nozzle sprinkler fed with water from a flexible hose that is rewound on the reel. The gun cart is mounted on wheels and travels along a straight line while operating. Terrain needs to be level side-to-side, so the gun cart can roll straight the length of the hose line toward the reel. Prior proper alley preparation can lead to reduced maintenance repair and labor costs. The unit is equipped with a high-pressure water piston or turbine powered winch that reels in an anchored cable or hose attached to the gun cart. Some high capacity units have a small auxiliary gasoline engine to power the reel (Gerston, 2000).

In additional to a lower initial investment, the traveling gun can also be utilized to dewater retention ponds; thus serving a dual purpose. It also may be easier to keep water out of the feed bunks than with a water truck that typically sprays water from outside the pen.

A disadvantage of the traveling gun is that without proper feedyard alley preparation, the gun cart may not pull sufficiently straight and can become entangled with fences or other structures and stop. This can create more frequent breakdowns, increased labor, repair, and maintenance leading to total dissatisfaction with the unit. It can temporarily block alleys resulting in disruption of day-to-day cattle movements. Currently, with the exception of automatic shut-off, the unit cannot be controlled automatically. Since the gun cart must travel uninterrupted toward the reel, more management is required, especially initially. Traveling gun sprinkler systems have been successfully used to irrigate cropland for years, which establishes them as a viable option for feedyard dust control.

Data and Methods

Fixed, operational and total costs are estimated for a traveling gun(s) sprinkler system for dust control. Investment costs for the traveling gun system included the traveling gun, booster pump, pipeline, freight on all components, in addition to the associated depreciation. Operational costs are a direct function of the number of hours the traveling gun(s) sprinkler system is operated. Energy, labor, system repair and maintenance are the components operational expenditures. Estimated fixed costs, as well as operational costs, are combined to determine the total costs. These costs include both the initial expenditures as well as expenses to operate the equipment on a daily basis.

Costs for installing a traveling gun(s) sprinkler system are estimated for 10,000, 30,000, and 50,000 head-capacity feedyards. Cost estimates from industry provided the capital expenditure data for similar equipment to apply 1/8 inch of water per day to the feedyard surface (Menik, 2006).

Fixed costs for a traveling gun(s) sprinkler system are comprised of the initial investment expenditure for each size feedyard with annualized costs based on a 20-year useful life at six percent interest. Depreciation is calculated using the straight-line method with no salvage value assumed after the useful life of the system.

Operational costs for the traveling gun(s) sprinkling system include energy, labor, and maintenance and repairs. Energy costs are the expenditures required to pump the water and are determined utilizing the following formulas:

KW = (.746 * Motor Horsepower) / 90% motor efficiency

Where: KW = kilowatt. # of kilowatts per hour

Total Energy Cost = KW * electricity cost * hours per year operated

Electricity energy costs are provided from two sources and averaged at $0.09 per Kwh (Betzen, 2006 and Boggs, 2006). Labor costs are $12.00 per hour. The 10,000-head yard would operate one traveling gun seven hours plus three man hours per day to move the equipment. Similarly, the 30,000 head yard would operate two traveling guns 10.5 hours plus nine man hours per day to move the equipment. The 50,000 head yard would operate three traveling guns 14 hours with 15 man-hours per day to move the equipment. The traveling gun(s) sprinkler system would operate six months of the year, April 15 to October 15, for a total of 184 days (Auvermann, 2006). A booster pump, on average, requires replacement every 10 years (Ekstrand, 2006). Booster pump costs include the actual cost of the pump plus installation and foundation expenses.

In this study, it is assumed a well is available with a sufficient flow capacity to operate multiple systems; therefore, expenditures do not include the installation of a new well to pump groundwater. There are no costs included for the installation of an irrigation reservoir.

The Southwestern Public Service Company Fed Cattle Survey for 1996 – 2000 is utilized to determine the five-year average cattle turnover rate for the 10,000, 30,000 and 50,000 head feedyards. Three turnover rates (1.75, 2.00, and 2.25) are used to adjust dollars per head capacity to dollars per head marketed for fixed, operational, and total costs.

Results

Fixed, operational, and total costs are identified for a traveling gun(s) sprinkler system for installation in three size feedyards: 10,000 head, 30,000 head, and 50,000 head. In each case, the design of the systems is sufficient to operate 1/8 inch of water per day to the feedyard surface.

Estimated fixed costs for a 10,000 head feedyard are projected at $45,292. This cost includes purchase of one traveling gun, booster pump, trenching and installation of pipeline, and freight, Table 1. The 30,000 head feedyard is estimated to have fixed costs of $96,306 comprised of two traveling guns, booster pump, trenching and installation of pipeline, and freight. In the 50,000 head feedyard, three traveling gun sprinkler systems are utilized at a fixed cost of $150,763.

High-pressure pipeline costs increase almost five-fold between 10,000 head ($5,292) and 30,000 head ($24,026) feedyards, Table 1. Pipe diameter size in the 10,000 head yard is six inches, whereas, it is six and eight inches with a larger portion being eight inches in the 30,000 head yard. In comparison, the 50,000 head yard ($51,220) pipe expenditures increase nearly ten-fold as opposed to the 10,000 head yard ($5,292). In the 50,000 head yard, six, eight and ten inch pipe is used with a majority being eight and ten inches.

Economies of scales are noted in the fixed cost of the three size feedyards. Fixed cost in dollars per head capacity were estimated at $4.53 in the 10,000 head feedyards, whereas, the 50,000 head yard had $3.02 in dollars per head capacity. This is a difference of $1.33 in fixed costs in dollars per head capacity.

Table 1. Estimated Fixed Costs for Traveling Gun(s) Sprinkler System, Booster Pump, Pipeline, and Freight for 10,000, 30,000, and 50,000 Head-Capacity Feedyards.

Head Capacity	Traveling Gun	Freight for Traveling Gun	Booster Pump	Freight for Booster Pump	Pipeline	Total Cost	Total Cost $/Hd Capacity
10,000	$33,025	$2,000	$4,785	$190	$5,292	$45,292	$4.53
30,000	$59,445	$4,000	$8,600	$235	$24,026	$96,306	$3.21
50,000	$84,214	$6,000	$9,050	$280	$51,220	$150,763	$3.02

On an annualized fixed costs basis in the 10,000 head feedyard, costs are projected at $6,213. These same costs for a 30,000 and 50,000 head feedyard are estimated at $13,177 and $20,682, respectively, Table 2. The economies of scale on an annualized cost per head basis are $0.21 between the 10,000 and 50,000 head feedyards. The differences between the 10,000 and 50,000 head yards are one versus three traveling guns purchased and the length and size of the pipeline.

Table 2. Projected Annualized Fixed Cost for a Traveling Gun(s) Sprinkler System over 20 years for 10,000, 30,000, and 50,000 Head-Capacity Feedyards.

Head Capacity	Total Cost	Annualized Projected Fixed Cost	Annual Depreciation	Total Projected Annualized Fixed Cost	Annualized Cost $/Hd Capacity
10,000	$45,292	$3,949	$2,265	$6,213	$0.62
30,000	$96,306	$8,396	$4,815	$13,177	$0.44
50,000	$150,763	$13,144	$7,538	$20,682	$0.41

Total operational costs are estimated at $10,458, $28,306 and $47,392 for the 10,000, 30,000 and 50,000 head feedyards, respectively. The economies of scale do not increase between the 30,000 and 50,000 head yards, Table 3. Under these assumptions, any gain in economy of scale in the larger yard created by lower pump and traveling gun costs per head are mostly offset by larger, more costly pipe.

Labor cost is the single largest operational expenditure for the three-sized feedyards. In the 10,000 head yard, labor costs are $6,624. Annual labor costs in the 30,000 and 50,000 head feedyards are $19,872 and $33,120, respectively, Table 3.

Table 3. Projected Annual Operational Costs for Traveling Gun(s) Sprinkler System over 20 years for 10,000, 30,000, and 50,000 Head-Capacity Feedyards.

Head Capacity	Energy Cost	Traveling Gun & Pump Maint & Repairs	Labor Cost	Operational Cost	Operational Cost $/Hd Capacity
10,000	$1,943	$1,891	$6,624	$10,458	$1.05
30,000	$5,044	$3,390	$19,872	$28,306	$0.94
50,000	$9,608	$4,663	$33,120	$47,392	$0.95

Projected fixed and operational costs are combined to determine the total costs to operate a traveling gun(s) sprinkler system to control feedyard dust emissions in the three size feedyards. The annualized fixed costs are $0.62, $0.44, and $0.41 per head capacity for a 10,000, 30,000, and 50,000 head feedyard, respectively, Table 4. Total cost in dollars per head capacity ranged from $1.67 for the 10,000 head yard to $1.36 for the 50,000 head yard.

Table 4. Estimated Fixed, Operational, and Total Costs on a $/Head Capacity for Traveling Gun(s) Sprinkler System based on a 20-year Useful Life for 10,000, 30,000, and 50,000 Head-Capacity Feedyards.

Head Capacity	Fixed Cost $/Hd Capacity	Operational Cost $/Hd Capacity	Total Cost $/Hd Capacity
10,000	$0.62	$1.05	$1.67
30,000	$0.44	$0.94	$1.38
50,000	$0.41	$0.95	$1.36

Three turnover rates, 1.75, 2.00, and 2.25, were used to adjust dollars per head capacity to dollars per head marketed for fixed, operational and total costs. A 10,000 head feedyard at a 1.75 turnover rate had fixed costs at $0.36, operational costs at $0.60 for a total of $0.95 per head marketed to install and operate a traveling gun(s) sprinkler system, Table 5. At the same time, a

50,000 head feedyard at the same turnover rate, 1.75, had fixed costs at $0.24 and operational costs at $0.54 for a total of $0.78 per head marketed to operate a traveling gun sprinkler system.

Table 5. Fixed, Operational, and Total Costs on a $/head Marketed for a Traveling Gun Sprinkler System based on a 20-year Useful Life for 10,000, 30,000, and 50,000 Head Capacity Feedyards and Three Turnover Rates.

Head Capacity	Turnover Rate (Hd Marketed/ Hd Capacity)	Fixed Cost $/Hd Marketed	Operational Cost $/Hd Marketed	Total Cost $/Hd Marketed
10,000	1.75	$0.36	$0.60	$0.95
	2.00	$0.31	$0.52	$0.83
	2.25	$0.28	$0.46	$0.74
30,000	1.75	$0.25	$0.54	$0.79
	2.00	$0.22	$0.47	$0.69
	2.25	$0.20	$0.42	$0.61
50,000	1.75	$0.24	$0.54	$0.78
	2.00	$0.21	$0.47	$0.68
	2.25	$0.18	$0.42	$0.61

Discussion

One topic to consider when purchasing a traveling gun(s) sprinkler system for feedyard dust suppression is governmental programs that may assist in purchasing the equipment. Prior to 2003, Environmental Quality Incentive Program (EQIP) funding was available for farmers, ranchers, and small animal feeding operations on a cost-share basis. In 2003, USDA Natural Resources Conservation Service (NRCS) designated EQIP monies for larger, Concentrated Animal Feeding Operations (CAFOs) to address environmental issues. “The first area of emphasis for Texas’ CAFO program under EQIP was atmospheric resource quality management, or ARQM, focusing exclusively on dust control from open-lot feedyards.” (Auvermann, 2005). However, since that time, no known organizations in the Texas Panhandle have applied for EQIP funds to utilize traveling guns. It is anticipated that no EQIP funding will be available for their use in the future (Sokora, 2006).

The annualized total expenditure including fixed and operational costs for operating a traveling gun(s) sprinkler system ranged from $1.67 to $1.36 for the three-sized feedyards. This compares favorable to the solid-set sprinkler where total costs per head-capacity varied from $2.70 to $2.09 (Guerrero et al., 2005) for similar feedyard sizes. However, a portion of the cost advantage is lost if feedyards utilize EQIP cost-share (up to 50% to a maximum of $450,000) available for solid-set sprinklers that traveling guns potentially may do not qualify for. The cost advantage of the traveling gun(s) sprinkler system is diluted further when feedyard managers make decisions based on head marketed which is generally double the one time capacity (SPS). Therefore, adoption of the traveling gun(s) sprinkler system is likely limited given the increased management, labor and maintenance requirement of the system relative to solid-set sprinkler(s). Traveling gun sprinklers are most appropriate where driving alleys are straight and level without obstructions to the gun cart. Should feedlot managers/owners voice an increased interest in the utilization of the traveling gun(s) sprinkler system for feedyard dust suppression with the USDA Natural Resources Conservation Service (NRCS), further discussion regarding EQIP monies would likely be considered.

References

"Beneficial Management Practices – Environmental Manual for Feedlot Producers in Alberta." Retrieved on May 26, 2006 from: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw5837?opendocument.

Auverman, B. 2006. Personal Communication. Texas Agricultural Experiment Station, Amarillo, Texas. May 15

Auvermann, B. and J. Sweeten. 2005. "Engineering Support for USDA's Environmental Quality Incentives Program (EQIP) for Feedyard Dust Control." Texas Agricultural Experiment Station, Amarillo, Texas. November 12.

Auvermann, B. 2003. "A Preliminary Assessment of the Net Economic Benefit of Solid-Set Sprinkler Used for Dust Control and Microclimate Modification."

Betzen, Melody. 2006. Personal Communication. Deaf Smith Electric Cooperative. Hereford, Texas. August 10.

Boggs, Greg. 2006. Personal Communication. Xcel Energy. Amarillo, Texas. August 10.

Davis, J.G., T.L. Stanton, and T. Haren. "May 1997. " Feedlot Manure Management." Colorado State Cooperative Extension. Publication No.1.220. Retrieved March 28, 2006 from: http://www.ext.colostate.edu/PUBS/livestk/01220.html.

Ekstrand, D. 2006. Personal Communication. Sun-Belt Pump & Supply. Ltd. July 26.

Gerston, J. 2000. "Hard-Hose Travelers: Versatile Workhorse On and Off-the Farm." Retrieved on March 23, 2007 from: http://www.irrigation.org/ibt/0006/p27.htm.

Guerrero, B., S. Amosson, and L. Almas. February 2006. "Economic Analysis of Solid-Set Sprinklers to Control Dust in Feedlots." Report prepared for the Air Quality Initiative. Texas A&M University Agricultural Research and Extension Center, Amarillo, Texas. 14pp.

Lorimor, J. 2003. "Open Feedlot Construction and Management for Water and Air Quality Protection." Retrieved on June 30 from: http://www.cals.ncsu.edu/waste_mgt/natlcenter/modules/Module%208.doc.

MacVean, D., D. Franzen, T. Keefe, and B. Bennett. 1986. "Airborne Particle Concentration and Meteorologic Conditions Associated with Pneumonia Incidence in Feedlot Cattle." American Journal of Veterinary Research. 47 (21) Dec. 1986: 2676-2681.

Menik, Karl. 2006. Personal Communication. Consolidate Pipe and Tube Co., Inc. June 22.

Nelson Irrigation. 2006. "Big Gun Nozzles." Retrieved on May 23 from: http://www.nelsonirrigation.com/products/index.cfm?id=5.

Sorkora, Gregory L. 2006. Personal communication. Zone Engineer, Natural Resource Conservation Service. Lubbock, Texas. July 14.

Southwestern Public Service Company. 1996 – 2000. “Cattle –Feeding Capitol of the World – Fed Cattle Survey.”

Queensland Government. 2003. “Feedlot Water Management Series: Dust Control.” Department of Primary Industries and Fisheries. Retrieved March 2, 2006 from: http://www.dip.qld.gov.au/environment/5243.html.