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In Search of the Ideal Water Line Cleaner

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INSIDE

Cleaning poultry drinking water systems can be difficult if systems are dirty or a biofilm slime has become established in the pipes, regulators, and water lines running from the well to the poultry houses. There have been many incidences in which the best daily water sanitation program was less than successful in protecting birds from disease challenges just because the water system was not completely clean before bird placement. The goal of every poultry producer should be to provide birds with the best water supply possible. Unfortunately if growers often use vitamins and other water additives, it is very possible that a biofilm has become established in the pipes and regulators in as little as two to three days.

Biofilms are composed of many types of bacteria and other organisms that live together in a sticky film inside pipes, regulators, and even the nipple drinkers. The biofilm then shields itself by secreting a thick mucous that is not easily penetrated by cleaners such as chlorine or acidifiers such as citric acid. The mucous can even neutralize the cleaner before it has a chance to kill harmful organisms. Then as the biofilm grows and becomes crowded, it releases bacteria into the water and to the birds.

One of the most eye opening cases that drives home the importance of good water sanitation was a turkey barn that had Bordetella positive poults. Bordetella is a bacterial respiratory infection that can set back a flock of turkeys and usually requires antibiotic treatment for successful recovery. The nipple drinker line was cut and a visual inspection of the line indicated no slime. The pipes looked clean. However, when the water regulator was opened, a thick algae growth was present on the pressure seal and the Bordetella was found thriving there (see picture p. 4). That is why if a producer even suspects his water supply or drinkers might be causing health issues in flocks, it is important to pick the right line cleaner and use it at an appropriate rate between flocks when the poultry houses are empty and no birds are present.

The biggest question is: What products give producers the most thorough cleaning for their water systems without damaging the equipment? While many growers have been trained to use products such as citric acid, research results are now showing that when a drinker system is dirty with bacteria, organic acids such as citric acid could be providing the bacteria a food supply and creating a bacterial challenge for new chicks and poults. If the biofilm contains yeast or mold, then lowering the pH of the water with citric acid could actually be creating a more favorable environment for the slime to thrive resulting in clogged drinkers. Most molds prefer a pH of 2 to 5.

Given the fact that many challenges can potentially be present in poultry house water systems, what is the best choice for optimizing line cleaning and eliminating

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all growth? This was the question that led to the evaluation of several line cleaning products. The objective of this project was to create a microbial rich environment that could potentially shield bacteria and other organisms from cleaners (just like biofilms do) and then determine what products were most effective in reducing or eliminating bacteria, yeast and mold.

Products were evaluated for their ability to kill oxygen loving (or aerobic) bacteria, yeast and mold in the presence of a heavy organic load. These microbes were chosen because they are typically present in contaminated water systems. In an attempt to simulate the slime seen in the Bordetella positive regulator, water containing algae was used for the test. The heavy organic load in this water simulated the challenge for cleaning tough biofilms.

The products tested included a citric acid product; CID 2000®, (20 % stabilized hydrogen peroxide with acetic acid); 35% hydrogen peroxide; Poultry PronTech™ (quaternary ammonium compound); Pro Clean™, (50% stabilized hydrogen peroxide); Proxy Clean™, (50% stabilized hydrogen peroxide); and 6% sodium hypochlorite or house bleach. Table 1 shows the test concentrations for each product.

Table 1. Test products

Product	Description of Products	Concentration Tested
CID 2000®	20% Stabilized hydrogen peroxide with acetic acid	2% Solution
Citric Acid	Feed grade citric acid	Two 1-lb. packs to a gal. of water makes the stock solution, then 1-oz. to a gal. of water
Hydrogen Peroxide	35% concentration	3% solution
Poultry Pron Tech™	0.0123 grams/50ml	100 ppm solution
Poultry Pron Tech™	0.05 grams/50 ml	400 ppm solution
Pro Clean™	35% Stabilized Hydrogen Peroxide	3% solution
Pro Clean™	35% Stabilized Hydrogen Peroxide	0.78% solution
Proxy Clean™	35% Stabilized Hydrogen Peroxide	3% solution
Sodium hypochlorite or household bleach	6% Concentrate	0.78% solution tested created by adding 1-oz. bleach to 128-ozs. or 1-gallon of water
Sodium hypochlorite or household bleach	6% Concentrate	0.073% solution tested this was made by adding 12-ozs. bleach added to 128-ozs. or 1-gal. of water to create a stock solution then 1-oz. of stock was added to 1-gallon of drinking water

The amount of cleaner required to give the final concentrations listed in Table 1 was added to each of two small jars (duplicates) containing 50 ml of water with an abundance of algae growth. Prior to adding the cleaners, the water in each jar was tested for the different microbes. Following cleaner addition the jars were held at room temperature until they were sampled at 4 and 24 hours. The pH of the samples was checked with a pH meter, while the aerobic plate counts (APC), yeast and mold counts were done using Petrifilm™.

The initial aerobic bacteria counts (APC) ranged from 2 million to 35 million colony forming units per milliliter (CFU/ml) (Table 2).

Table 2. Bacteria count results of testing different cleaning products on algae water

Product	Pre-Treatment Aerobic Bacteria (CFU/ml)	Aerobic Bacteria 4 hours after adding products (CFU/ml)	Aerobic Bacteria 24 hours after adding products (CFU/ml)
Control	10,400,000	12,750,000	24,650,000
CID 2000® 2% solution	8,000,000	105	<10
Citric Acid	36,500,000	36,200,000	21,800,000
Hydrogen Peroxide - 3% solution	5,500,000	294,000	115
Poultry PronTech™ 100 ppm	13,100,000	465,000	5,382,500
Poultry PronTech™ 400 ppm	6,500,000	575,000	261,500
Pro Clean 0.78% solution	24,300,000	490,000	53,800
Pro Clean 3% solution	7,700,000	82,000	<10
Proxy Clean™ 3% solution	2,100,000	166,500	<10
Bleach 0.073% solution	7,600,000	166,500	1,271,000
Bleach 0.78% solution	9,700,000	109,000	138,000

Counts from untreated (control) water increased slightly at both 4 and 24 hours, which showed that conditions favor survival of aerobic bacteria. When the products were compared at four hours post treatment, counts from the CID 2000® hydrogen peroxide treated water had the greatest reduction in bacteria counts with only 105 CFU/ml remaining. At 4 hours post treatment counts from the citric acid treated water showed no reduction. Although all the other products tested reduced bacteria counts, several thousand CFU/ml survived and this level is not acceptable for drinking water systems because it serves as a reservoir of bacteria to re-establish biofilms. At 24 hours, no bacteria were detected in water treated with the CID 2000®, ProClean™ 3%, or ProxyClean™ 3%. The hydrogen peroxide 3% solution also had dramatic reduction in bacteria counts at 24 hours. The bleach solutions tested showed minimal effectiveness in reducing bacterial counts, as did the PronTech™.

Yeast and mold counts from control samples decreased by about tenfold at 4 hours, but did not further decrease at 24 hours (Tables 3 and 4). Since yeasts and mold prefer to grow in low pH's (acid conditions), these counts may reflect the fact that pH values for the water used were higher than 7 (alkaline) (Table 5).

Table 3. Yeast count results of testing different cleaning products on algae water

Product	Pre-Treatment Yeast Levels (CFU/ml)	Yeast Levels 4 hours after adding products (CFU/ml)	Yeast Levels 24 hours after adding products (CFU/ml)
Control	2,800	200	145
CID 2000® 2% solution	400	<10	<10
Citric Acid	15,000	480	390
Hydrogen Peroxide - 3% solution	700	<10	<10
Poultry PronTech™ 100 ppm	1100	160	160
Poultry PronTech™ 400 ppm	135	135	95
Pro Clean 0.78% solution	3500	500	30
Pro Clean 3% solution	600	<10	<10
Proxy Clean™ 3% solution	2,500	<10	<10
Bleach 0.073% solution	400	65	100
Bleach 0.78% solution	400	70	120

Table 4. Mold count results of testing different cleaning products on algae water

Product	Pre-Treatment Mold Levels (CFU/ml)	Mold Levels 4 hours after adding products (CFU/ml)	Mold Levels 24 hours after adding products (CFU/ml)
Control	1,000	120	105
CID 2000® 2% solution	200	<10	<10
Citric Acid	1,400	905	155
Hydrogen Peroxide - 3% solution	400	<10	<10
Poultry PronTech™ 100 ppm	400	30	25
Poultry PronTech™ 400 ppm	900	30	25
Pro Clean 0.78% solution	100	<10	<10
Pro Clean 3% solution	600	<10	<10
Proxy Clean™ 3% solution	400	<10	<10
Bleach 0.073% solution	200	<10	10
Bleach 0.78% solution	300	20	15

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Table 5. pH results of testing different cleaning products on algae water

Product	Pre-Treatment pH Levels	pH Levels 4 hours after adding products	pH Levels 24 hours after adding products
Control	7.91	8.04	8.01
CID 2000® 2% solution	7.88	5.86	6.11
Citric Acid	7.81	7.49	8.08
Hydrogen Peroxide - 3% solution	7.79	7.94	8.16
Poultry PronTech™ 100 ppm	7.86	8.62	8.25
Poultry PronTech™ 400 ppm	7.70	8.74	8.82
Pro Clean 0.78% solution	7.98	8.08	8.27
Pro Clean 3% solution	7.83	7.85	8.07
Proxy Clean™ 3% solution	7.74	7.86	7.99
Bleach 0.073% solution	7.92	8.23	8.36
Bleach 0.78% solution	7.85	8.19	8.39

Initial yeast ranged from 135 to 15,000 CFU/ml (Table 3). While all yeast counts except the PronTech™ 400 decreased at 4 hours, levels were undetectable for the 2% CID® 2000, the ProClean™ 3%, ProxyClean™ 3% and hydrogen peroxide at both 4 and 24 hours. Interestingly, yeast counts from bleach treated samples decreased at 4 hours, but increased slightly at 24 hours.

Mold counts from pre-treatment samples ranged from 200 to 1,400 CFU/ml (Table 4). More products showed effectiveness in reducing mold counts than yeast counts (Table 3). Mold counts from CID® 2000, both levels of ProClean™, ProxyClean™, 0.073% bleach solution and 3% hydrogen peroxide decreased to undetectable levels by 4 hours, while counts from citric acid, PronTech™ and 0.78% bleach treated samples decreased less.

The initial pH for the different dirty water solutions was above pH neutral (7) which is not uncommon for many water supplies (Table 5). There were no obvious trends in pH among the treatments. The control showed a slight increase in pH at 4 and 24 hours. The CID 2000® had a drastic reduction in pH at 4 hours, but at 24 hours it increased. The citric acid had an initial lowering of pH, but at 24 hours it increased. Hydrogen peroxide increased the pH at 4 and 24 hours. Both PronTech™ rates had an increase in pH at 4 and 24 hours and this would be expected for ammonia-based products. The Pro Clean at both rates also increased the pH at 4 and 24 hours, as did the Proxy Clean™ and both bleach rates.

Conclusion

The products which showed the most effectiveness in virtually eliminating bacteria, yeast and mold were 2% CID 2000®, 3% ProClean™, 3% ProxyClean™ and 3% hydrogen peroxide (35% concentrate). Citric acid had little impact on the bacteria. The yeast and mold levels tended to become lower no matter what the treatment but were reduced to undetectable levels by the same products that reduced the bacteria. It was also interesting to note that it took up to 24 hours to have the most impact on bacteria levels with the most effective products with the exception of CID 2000®. Knowing that mold typically prefers acidic pH and the samples were slightly alkaline, the environment was not very favorable for mold. The high pH PronTech™ solutions were not very effective but the test was somewhat an unfair test since low concentrations PronTech™ solutions (100 and 400 ppm) were compared to 3% hydrogen peroxide solutions. Future work will focus on stronger concentrations of PronTech™ since it is a high pH product that may have great value in high pH water. Higher concentrations of bleach were not used since strong bleach solutions are known to be damaging to water line equipment.

The take home message from this project is water systems which contain a great deal of bacterial growth and slime may very well need products at stronger concentrations to eliminate the challenge. Otherwise, bacteria may remain in concentrations that can return to high levels once the cleaner is removed from the system. Weak citric acid solutions are not good line cleaner choices for dirty systems. To achieve 3% solution concentrations, producers can mix 1.5 gallons of product in 50 gallons of water then use a 1/4th hp submersible pump to add the cleaner at the medicator connection. To determine if water systems might need extra strength cleaning, take apart a regulator. If a coating of slime is present and performance issues have existed in previous flocks that were not management related, then thorough water line cleaning is recommended. A final note, always check with your equipment supplier prior to using any product in your drinker system.

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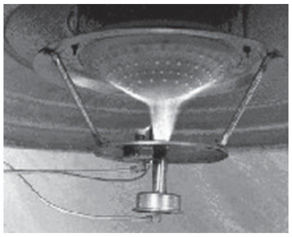

Applied Broiler Research Farm Report: Propane Usage Before and After Renovation[1]

Introduction

The Applied Broiler Research Farm (ABRF) is a 4-house commercial-scale broiler farm constructed by the University of Arkansas in 1990 with the unique capability to closely monitor gas usage. In January 2006, a complete and total renovation of the farm began. This article on gas (propane) usage is the first of a planned series of "before and after" reports on ABRF performance in various areas.

Farm Background

Before renovations, the farm consisted of four 16-year-old 40 x 400' broiler houses that had received only minimal improvements over the years. The houses were completely stripped down to where only the trusses, roofs, and end walls remained. The drop ceilings also remained intact in the two wood truss houses. Drop ceilings were installed in the two steel truss houses and enough loose fill insulation blown into the attic to match the R-19 in the two houses that already had drop ceilings. Curtain sides were replaced with solid sidewall construction on all houses. New feeders, new drinkers, new cool cell systems, crossover foggers and tunnel ventilation fans for summer cooling were installed as well as new north sidewall fans and vent door air inlet systems for minimum ventilation. The farm was completed re-wired and new automatic controllers, backup thermostats, and light dimmers were installed in each house. A gas chlorination system was installed along with an additional pump system that injects Poultry Water Treatment (PWT; Jones-Hamilton Co.) to treat the farm's well water supply.

The farm resumed growing broilers in April 2006. Two flocks of small birds (38 days old) and two flocks of larger birds (49 and 50 days old) were grown. One flock each was placed in April, June, August, and October of 2006. Propane usage data and temperature data from the National Weather Service are reported below.

Gas Bill as a Percentage of the Chicken Check

Throughout 2001, 2002 and until August of 2003 gas prices remained constant at 0.88 cents per gal (Table 1).

Table 1. Propane costs at the Applied Broiler Research Farm (2001-2006)

	April	June	August	October
Year	**Propane Cost ($/gal)**	**Propane Cost ($/gal)**	**Propane Cost ($/gal)**	**Propane Cost ($/gal)**
2001	0.88	0.88	0.88	0.88
2002	0.88	0.88	0.88	0.88
2003	0.88	0.88	0.93	0.93
2004	1.03	1.03	1.03	1.42
2005	1.19	1.19	1.19	--
2006	1.52	1.37	1.37	1.31

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[1] Mention of company or trade names does not constitute endorsement by the University of Arkansas Cooperative Extension Service or Center of Excellence for Poultry Science and does not imply their approval to the exclusion of other companies or products that may be suitable.

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August and October flock prices climbed to 0.93 cents per gal. Prices continued to climb during 2004 with the price of gas for the April, June, and August flocks at $1.03 per gal and increasing to $1.42 for the October flock. By April 2005, prices had dropped back to $1.19 per gal and remained steady through the August 2005 flock. There was no October flock 2005 because the farm was shut down in preparation for renovations. By April 2006, when renovations were complete and the farm came back on line, gas prices were $1.52. Prices dropped to $1.37 for the June and August flocks and dropped yet again for the October flock to $1.31.

The price of propane and the number of days when supplemental heat was required both had an effect on the percentage of the settlement check devoted to paying the gas bill (Table 2).

Table 2. Propane Costs and heating days at the Applied Broiler Research Farm (2001-2006)

	April		June		August		October	
Year	**%[1]**	**HD[2]**	**%**	**HD**	**%**	**HD**	**%**	**HD**
2001	26	16	5	1	7	0	24	27
2002	17	20	7	0	5	0	24	24
2003	12	22	7	4	2	0	28	24
2004	41	22	7	1	8	3	30	18
2005	35	26	14	0	7	0	--	21
2006	26	16	4	0	1	0	21	26

[1] Percentage of the settlement check spent for propane

[2] Days with lows below 65 degrees F (from National Weather Service)

The National Weather Service data shown suggest that outside temperatures in April and June of 2006 were warmer than most of the previous five years. October temperatures appeared to be slightly colder than previous years and little supplemental heat was require in August. The June and August flocks of 2006 (after renovations) accounted for the least percentage spent on fuel of any year during the 6-yr period. This is due, in part, to tighter houses, solid side walls, better insulation, and better control of the ventilation system. The 0.09 ¢/lb increase in pay per pound of salable meat is also partly responsible because the 2006 chicken checks were larger than any of the previous years' checks.

Gallons of Gas Required

Propane usage data before and after renovation by placement month are shown in Figure 1. The number of days when heat was required (Figure 2) and the number of days when outside temperatures were at or below freezing (≤32ºF) (Figure 3) are also shown. In all three figures the data listed as "before" represent an average of the previous 5 years (i.e. 2001-2005), while data listed as "after" are 2006 data.

Figure 1. Gallons of Propane Used Before and After Renovations at ABRF

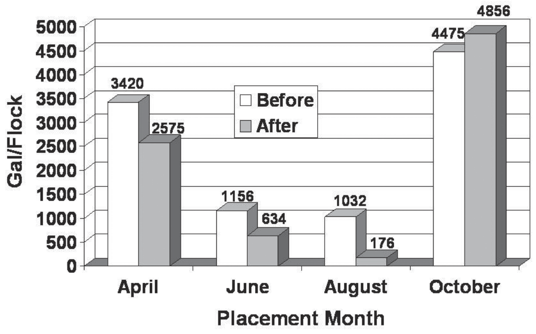
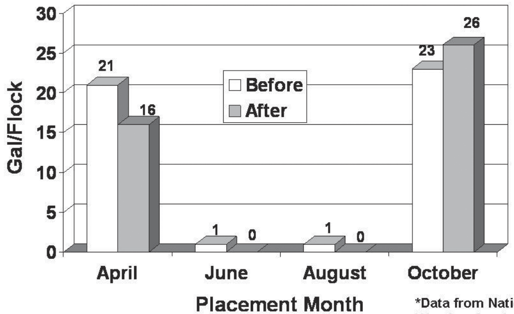


Figure 2. Days Requiring Heat Before and After Renovations at ABRF*

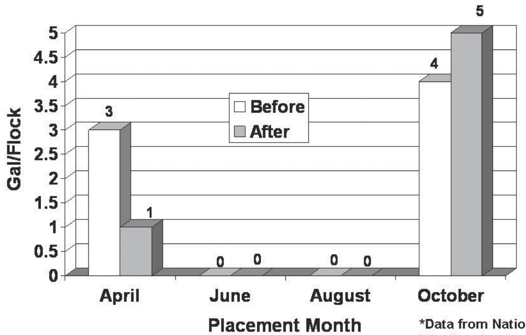


*Data from National Weather Service

A big unknown after the renovation was how would gas consumption change compared to before the renovation. Since at the creation of this article we have not been through the cold, winter season, peak demand usage is still unknown but that information will eventually be available for dissemination.

Fewer gallons of propane were used in April, June and August placed flocks in 2006 than in the average previous 5 years (Figure 1). There were fewer days in April, 2006 requiring heat (Figure 2) and fewer days with freezing temperatures (Figure 3) than in the '01-'05 average, which could account for lower propane usage figures. However, temperatures were in June and August were virtually identical when 2006 was compared with the average of the previous 5 years. Yet, as compared with the average of the previous five years, less propane was used in June and August of 2006. This apparent increase in energy efficiency is likely due to renovation. In October there were more days requiring heat (Figure 2) and more days with freezing temperatures (Figure 3) in 2006 than in the average of the previous five years. Yet the newly renovated houses only 8.5% (381 gal.) more propane than the average of the previous five years. These data again suggest that renovations made the houses more energy efficient.

Figure 3. Days with Freezing Temperatures (<32F) Before and After Renovations at ABRF*



*Data from National Weather Service

Summary

Presented is gas usage data before and after renovations at the University of Arkansas' ABRF. Many poultry producers have recently gone through major renovations on their farms similar to those at the ABRF. This information, along with data currently being collected should be of interest to producers and provide a clear "before and after" assessment of gas usage and help determine the true value of farm renovation.

References

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Feasibility of On-Farm Broiler Litter Combustion

Introduction

Poultry litter is a resource that many growers have consistently used to fertilize pastures. However, poultry growers in sensitive watersheds are searching for alternatives to conventional land application. Litter can be burned in a furnace and the heat can be used for space-heating the broiler houses and might offer an alternative to land application. Propane or natural gas saved by utilizing the heat from combustion of litter might provide an economic incentive to justify the investment in the furnace system. However, it is important to examine the facts before investing in an on-farm litter burning furnace.

Therefore, we decided to test a litter burning furnace. The purpose of this test was to determine if on-farm litter burning is feasible. An additional objective was to aid growers in making decisions about furnaces by providing details on thermal performance (i.e., the rate of heat output and the efficiency of the furnace), bulk material flow (i.e., daily and annual amounts of litter needed and ash

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produced), economic implications, management requirements and environmental repercussions. This article provides a summary of the results from the demonstration.

Furnace System Description

A broiler litter-fired furnace prototype, fabricated by Lynndale Systems, Inc., Harrison, Arkansas, was used in the test. The furnace was installed at House 1, UA Applied Broiler Research Farm (ABRF), near Savoy, Arkansas. The furnace used a direct combustion process with fan-forced delivery of combustion air. House air was drawn through air filters into the furnace and through an air-to-air heat exchanger. This arrangement was designed to extract energy from the hot exhaust gases and to transfer the energy to the air stream which was directed back into the house. Six, 18-inch high velocity stirring fans were used to promote distribution of the heated air longitudinally within the house.

Automatic control of the furnace components was accomplished using an electronic data logger (Campbell Scientific, model 21X, Logan, Utah). Whenever the house thermostat called for heat, a linear actuator moved a flapper valve to direct the heated air into the house (and exhausted the heated air when the thermostat was satisfied).

The broiler litter used as fuel in the test was taken from the Savoy farm during an annual cleanout in spring, 2005. It was stored for over a year in a bunker (covered pile on a concrete pad) adjacent to House 1. During the furnace test, litter was removed from the pile using the front-end loader on a tractor as needed and placed in a large hopper that could hold about 1.5 front-end loader buckets. A chain conveyor moved the litter from the outside hopper to a small surge tank above the furnace. As the furnace consumed fuel, it was metered into the combustion chamber.

Ash accumulated in an ash bin which was cleaned out manually every 1-3 days of operation. After removal, the ash was stored in covered plastic bins.

Testing:

The furnace system was operated during 2 grow-outs of birds from August 1, 2006 to November 24, 2006. The furnace supplied heat, as needed, to House 1 (a solid-side wall, tunnel ventilated house) at the ABRF. Measurements of fuel use, ash accumulation and heat extracted were obtained using digital scales, thermocouple probes and electronic data collection. The data were analyzed to document furnace performance and to provide a basis for assessing the feasibility of the system.

The data in Table 1 were from the second growout of the demonstration when the furnace prototype was operated automatically. In the table, the column labeled ‘Heat Extracted’ represents the total amount of heat generated from the litter burned on that day, while the column labeled ‘Heat Delivered’ represents the amount of heat actually delivered into the chicken house. Due to mild weather, the broiler house thermostat did not call for heat in the latter part of the growout when the birds were large. On these days, the furnace was often operated with the heat exhausted outside the house. ‘Peak Output’ is the maximum amount of heat generated per hour on that day. The data under ‘Cumulative Litter Consumed’ and ‘Cumulative Ash Produced’ represent running totals of the mass of litter burned and ash produced during the test.

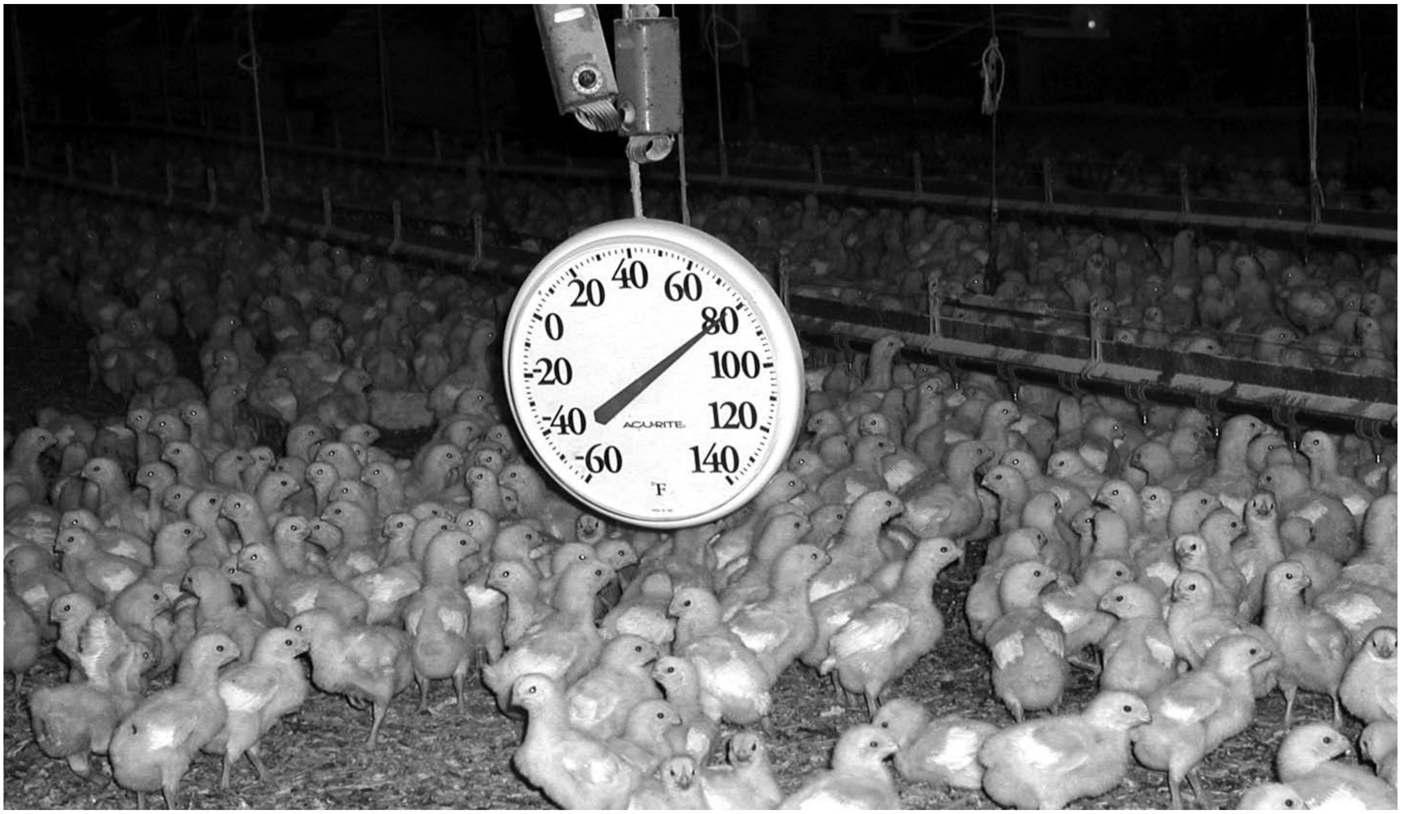

Table 1. Performance of furnace during the second flock of the test

Date	Time of Operation (h)	Heat Extracted (btu)	Heat Delivered (btu)	Peak Output (btu/hr)	Cumulative Litter Consumed (lb)	Cumalitve Ash Produced (lb)
10/07/2006	6.0	30,797	6060	18,780	0	0
10/09/2006	9.2	276,753	211,156	61,980	607	0
10/10/2006	0.9	12,674	12,409	22,140	607	133
10/11/2006	4.0	99,093	95,790	57,000	977	133
10/13/2006	10.0	359,814	244,809	87,060	1,584	133
10/14/2006	10.7	362,926	309,754	78,360	1,840	133
10/16/2006	5.6	247,771	194,230	93,000	2,736	133
10/17/2006	6.9	229,482	8,360	60,300	2,809	463
10/19/2006	5.7	99,093	95,790	77,340	3,416	463
10/23/2006	6.9	218,327	218,317	62,040	4,023	463
10/24/2006	10.5	270,928	270,655	61,860	4,630	725
10/25/2006	10.5	157,227	157,191	77,400	5,237	725
10/26/2006	13.4	198,783	198,717	45,120	5,237	725
10/31/2006	17.7	919,988	0	70,860	6,451	840
11/01/2006	16.3	651,106	0	62,580	7,058	980
11/02/2006	6.5	90,585	0	34,980	7,665	980
11/03 - 04/2006	33.7	1,201,344	964,070	84,000	10,093	1,480
11/09/2006	14.9	835,880	0	92,400	11,307	1,480
11/10/2006	12.8	836,822	0	87,840	12,521	1,797
11/13/2006	14.8	863,452	0	81,600	13,735	1,797
11/14/2006	10.7	48,298	0	84,300	14,949	2,034
11/15/2006	6.9	309,073	0	69,780	15,556	2,034
11/16/2006	12.4	818,563	0	90,360	16,770	2,203
11/17/2006	7.4	335,977	0	80,820	17,377	2,203
11/18/2006	4.1	115,449	0	64,080	17,377	2,424
11/20/2006	11.8	713,613	0	78,000	18,591	2,424
11/21/2006	18.8	1,073,949	0	82,500	20,412	2,758
11/22/2006	10.4	428,683	0	84,120	21,019	2,880
TOTAL	**299**	**12,243,450**	**2,987,308**			

Over the 7 week period, the furnace was operated about 300 hours and produced over 12 million btu of heat (equivalent to about 133 gallons of propane). Approximately 10 tons of litter was combusted, producing an accumulated ash mass of about 1.4 tons (3 cubic yards). The average litter feed-rate was 70 lb/hour and the peak heat output was 93,000 btu/h. The furnace system efficiency (assuming litter has an energy content of about 4500 btu/lb) was 13%.

Properties of Litter and Ash:

Samples of litter and ash were collected and analyzed. The properties are summarized in Table 2 (right).

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Table 2. Lab analysis results for litter and ash samples

Constituent	Litter	Ash
	Concentration (%, as-is basis, by weight)	
Moisture	15.2	2.7
Ash	21.0	89.2
Carbon	31.9	4.2
Hydrogen	5.7	0.6
Nitrogen	4.0	0.6
Sulfur	0.6	1.7
Oxygen	40.5	18.0
Phosphorus	3.1	9.7
Potassium	3.7	10.9
Energy (btu/lb)	5500	360

The energy content listed is for completely dried litter. Net energy values would be reduced to account for moisture normally present in litter. These test results for litter energy are consistent with other data which suggests a general net energy for broiler litter of about 4500 btu/lb. Litter quality will affect net energy. Wetter litter will have lower net energy content. Although we have not measured it, we can presume that litter that has not been stored for a long storage period would have higher energy content.

The fact that the ash includes 4% carbon indicates that either the litter was not completely combusted or that some unburned fuel sifted into the ash pan. Design improvements could be targeted to capture this energy to improve furnace system efficiency.

Since the process of burning removes organic matter (carbon), the ash tends to accumulate and concentrate the mineral, non-volatile litter constituents. Thus, we would expect ash would contain higher concentrations of minerals compared to the original litter. The elevated phosphorus (P) content has both pro's and con's. Litter derived P that remains in the ash is one reason that farmers in sensitive watersheds should probably not apply ash as a soil amendment unless soil tests indicate that the receiving crop does indeed need supplemental P. Therefore, most growers will be looking for an off-farm, out-of-watershed market for the ash. The elevated P content would make the material more attractive as a fertilizer to potential buyers outside the region.

Emissions and Air Quality Impacts:

Emissions out of the stack have important implications. Emissions of certain gases provide an indication of the extent of combustion. Other gases may contribute to air pollution. Thus, the quality of the stack gases needs to be checked so that we can insure that we are simply trading water pollution problems for air pollution problems. In addition, emissions problems might lead to regulation of such furnaces in the future.

The contents of the exhaust stack were spot checked periodically during the test. A portable combustion analyzer was used to probe the gas and measure its constituents. The results are listed in Table 3 below.

Table 3. Emissions test results

	Consitutent concentrations in Stack Gases		
Emissions Test Date	Oxygen (%)	Carbon Monoxide (ppm)	Nitrous Oxide (ppm)
8/15/2006	14.4	4967	101
8/29/2006	17.4	1523	51
9/26/2006	16.5	5833	79
10/23/2006	15.9	7106	70
10/31/2006	16.8	4397	86
11/10/2006	14.8	7095	99
11/20/2006	14.1	7742	88

The measured levels of carbon monoxide (CO) were excessive. This gas is an intermediate combustion product that contains a lot of energy. Its presence at these concentrations represents lost heat and incomplete combustion. The potential exists to improve combustion in subsequent furnace designs so that CO levels are reduced and more energy (improved system efficiency) is extracted.

Levels of nitrous oxide (NO) were not excessive. Emissions of NOx from other sources (such as automobiles) contribute to air pollution in many urban areas. Changes to furnace design, particularly those that may lead to more complete combustion, could inadvertently increase NO emissions. So, this gas should continue to be monitored in tests following any combustion design changes.

The laboratory analysis of the litter indicates that it is composed of approximately 21% ash (inert minerals that cannot be combusted). In our testing, we were only able to recover about 12% of the litter weight as ash. The difference may be caused by very small particles of ash being exhausted up the stack (particulate emissions). Particulate emissions were not measured in this project. Further study is needed to see if particulate emissions represent a significant transport process that might carry litter constituents (such as minerals or trace metals) from the furnace to surrounding land.

Management Requirements:

During the second flock, when automatic controls were used, the furnace operation required one full-time operator. The operator was needed since the test had special monitoring/measurement requirements. While some mechanical failures did occur which interrupted the operation of the furnace, these problems should be fixed before a commercial system is on the market.

In routine operation, growers would not need the sophisticated monitoring equipment used in the test. Growers would probably need to add litter to the hopper approximately 2-4 loads per day, depending upon the heat demand (how cold it is outside and how big are the birds). While at the furnace to load litter, the farmer would likely check furnace operation and verify that all was well. This should take about 15-30 minutes of labor per day. Manual unloading of ash should take about 30 minutes every 1-3 days. However, a commercial furnace may include automatic ash handling.

Economic Feasibility

The demonstration was successful in showing the technical feasibility of burning 100% litter in a direct-combustion furnace on the farm. Yet, the total heat delivery rate and system efficiency were lower than we had hoped. Modifications to the design of the furnace we tested might result in improved performance, increasing peak heat output and efficiency.

We can make some estimates as to the needed furnace performance that will result in a system that will pay for itself. Let's say that a grower decides to purchase a litter furnace and expects the furnace to eliminate about 80% of the annual fuel (e.g., propane) use for space heating. What furnace heat rate would meet this 80% requirement? The data in Table 4 below are based upon gas usage from the ABRF over 15 flocks and show that a furnace heat rate of 175,000 btu/h would meet about 40% of the annual load operating on its own and about 80% of the annual load when supplemented with existing propane heaters. So, if the target is 80% fuel savings, then the furnace needs to meet a 175,000 btu/h specification.

Table 4. Cumulative heat load and annual propane use offset by furnaces of various heat ratings

Heat Rate Capacity (btu/h)	Cumulative Heat Load (%)	Annual Propane Offset (%)
60,000	4.6	38
75,000	7.9	45
100,000	15.2	57
125,000	23.9	66
150,000	33.2	74
175,000	42.5	80
200,000	51.4	85
250,000	66.6	91
300,000	78.1	95
350,000	86.1	97
400,000	91.4	99
500,000	97.0	100
600,000	99.0	100

The prototype furnace we tested only had a peak heat output of 93,000 btu/h. An increase is needed to be able supply enough heat to meet the targeted fuel savings. A furnace can generate more heat either by (a) burning fuel at a faster rate, or (b) extracting more heat from each pound of fuel (that is, a better efficiency). Table 5 below shows how projected furnace output increases with increases in fuel feed-rates and furnace efficiencies. To get to 175,000 btu/h, a furnace could be designed to burn 100 lb/h with an improved 40% efficiency. Actually, both of these goals should be attainable in a commercial furnace.

Table 5. Furnace heat delivery rate as a function of litter input (or feed-rate) and system efficiency. Assumes litter energy of 4500 btu/lb

System Efficiency	Peak Litter Input Rate (lb/h)						
	50	75	100	125	150	175	200
	Heat Rate Delivered (btu/h)						
10%	22,500	33,750	45,000	56,250	67,500	78,750	90,000
20%	45,000	67,500	90,000	112,500	135,000	157,500	180,000
30%	67,500	101,250	135,000	168,750	202,500	236,250	270,000
40%	90,000	135,000	180,000	225,000	270,000	315,000	360,000
50%	112,500	168,750	225,000	281,250	337,500	393,750	450,000
60%	135,000	202,500	270,000	337,500	405,000	472,500	540,000
70%	157,500	236,250	315,000	393,750	472,500	551,250	630,000
80%	180,000	270,000	360,000	450,000	540,000	630,000	720,000
90%	202,500	303,750	405,000	506,250	607,500	708,750	810,000
95%	213,750	320,625	427,500	534,375	641,250	748,125	855,000

Assuming then, that a commercial furnace is available that puts out 175,000 btu/h and can reduce conventional fuel costs by 80%, what are the economic ramifications? A typical broiler house in northwest Arkansas requires about 5000 gallons of propane per

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year for space heating. An 80% reduction in propane consumption would represent a substantial dollar amount. Depending upon the price you are paying for propane, these savings could provide a net cash flow that could be invested in the litter fired furnace.

The data in Table 6 below shows the total present value of projected fuel savings over a 7 year period. For example, if propane costs $1.20 per gallon and the furnace is capable of offsetting 80% of propane use, then the total present value of those fuel savings is $24,000, based on an interest rate of 8.5% and a 7 year planning horizon. Under this scenario, the grower could afford to invest (or borrow) as much as $24,000 for the furnace and expect the fuel savings to pay the note.

Table 6. Total present value (8.5% interest) of fuel savings occurring over a period of 7 years, as a function of propane costs and percentage of annual heat load offset by the furnace

Propane Costs Offset (%)	**Propane Cost ($/gallon)**						
	$0.90	**$1.00**	**$1.10**	**$1.20**	**$1.30**	**$1.40**	**$1.50**
	Present Value of Projected Fuel Savings over the Period						
10	2,303	2,559	2,815	3,071	3,327	3,583	3,839
20	4,607	5,119	5,630	6,142	6,654	7,166	7,678
30	6,910	7,678	8,446	9,213	9,981	10,749	11,517
40	9,213	10,237	11,261	12,284	13,308	14,332	15,356
50	11,517	12,796	14,076	15,356	16,635	17,915	19,194
60	13,820	15,356	16,891	18,427	19,962	21,498	23,033
70	16,123	17,915	19,706	21,498	23,289	25,081	26,872
80	18,427	20,474	22,521	24,569	26,616	28,664	30,711
90	20,730	23,033	25,337	27,640	29,943	32,247	34,550
95	21,882	24,313	26,744	29,176	31,607	34,038	36,469

Clearly there are potential scenarios that provide economic feasibility for litter fired furnaces. The grower will, however, need to make sure that the purchase/installation costs do not exceed the fuel savings potential of the furnace during a reasonable payback period. Growers will need to inspect the manufacturer's specifications for the furnace heat rate capacity, fuel feed-rate and efficiency to see if propane savings will meet expectations.

Fuel and Ash Handling Projections:

For a grower interested in a litter-fired furnace, an additional question may be "How much litter and ash will I need to handle?" If we assume a litter-fired furnace has a 40% efficiency rate and our target is a reduction of propane usage by 80%, then about 100 tons of litter would need to be stored for fuel. This amount of litter is about the amount of litter produced by a 40 x 400 ft house annually. However, less storage capacity would be needed if litter cleanouts occur more frequently than once per year.

To store 100 tons of litter, a grower could build a low-cost temporary storage adjacent to the poultry house and furnace. A pile that is 20 ft wide at the bottom, would need to be approximately 80 ft long to store 100 tons. A heavy duty plastic tarp would be required to keep rain off the litter during storage (see Avian Advice 2(1):12-15). Remember that litter should not be stored at depths more than 5 ft to avoid spontaneous combustion in the pile.

We estimate that burning 100 tons of litter per year would produce about 12 tons of ash. Ash has a density of approximately 45 lb/ft3, which means that about 20 cubic yards of ash would need to be marketed or disposed of each year. The grower would need enough ash storage capacity to handle ash generated. The costs to transport ash should be much less than for transporting litter itself. The mass reduction is 8:1 and the volume reduction is 10:1 for the ash produced from burning litter. However, the consideration of what to do with ash should be determined prior to beginning furnace operation. Potential markets for litter ash include its use as an additive in concrete, and for use in fertilizer manufacture.

Conclusions:

An existing litter-fired furnace prototype is capable of burning broiler litter at a rate of nearly 1 ton per day (peak). This technology is a potential alternate use for poultry manure. In sensitive watersheds, its use could shunt many tons of litter from land application to on-farm combustion. As a BMP, it has the potential to decrease the movement of phosphorus and other nutrients from upland areas to surface waters.

System performance of the tested prototype would need to be improved in order to make the system economically feasible. Simple design improvements, if implemented by the manufacturer, could increase system efficiency to 40% and increase fuel feed-rate to 100 lb per hour. Such improvements would mean that the furnace would likely reduce costs for propane (or natural gas) for space-heating by approximately 80% annually. Fuel savings of this magnitude are significant.

Depending upon the grower’s other costs and required return on investment, these savings may provide sufficient net cash flow to pay-off the investment in the furnace system.

Ash markets need to be further explored. Significant quantities of ash will be produced by the litter-fired furnace. Ash should not be land applied in sensitive watersheds. Air quality impacts should continue to be assessed. Particulate and NO emissions are of concern. Any subsequent testing on private farms should include emission monitoring.

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Wild Bird Control: Why and How

All wild birds (except pigeons, house sparrows and starlings) are protected by federal and state laws.

You may NOT trap, kill or possess protected species without federal and state permits

Introduction

Wild birds can be a nagging problem on any poultry farm. Wild birds can create a mess with their droppings, consume feed, contaminate feed and damage insulation (Berry, 2003). Wild birds have also been shown to carry Newcastle disease, coccidiosis, Salmonella, fowl pox, West Nile Virus, fowl cholera, Mycoplasma galisepticum (MG), round worms, tape worms, Northern Fowl Mites and several other maladies affecting poultry (McLean, 1994). Clearly, wild birds are undesirable in or around poultry houses. However, before beginning any effort to control wild birds, it is important to understand effective approaches and the legal limits.

Controlling wild birds legally

It may be tempting to take what appears to be the quickest, easiest way to eliminate wild birds (i.e. shoot them, trap them, or poison them). Yet, this approach carries some heavy legal penalties (USFWS, 1992).

All wild birds (except pigeons, house sparrows and starlings) are protected by federal and state laws. You may NOT trap, kill or possess protected species without federal and state permits (USFWS, 2002). Furthermore, regulatory officials are SERIOUS about enforcing these laws.

One Georgia cattle company took the direct approach and spread poison corn around a pond on their property to kill nuisance birds. The tainted corn resulted in the death of over 3,000 birds of various species. The cattle company paid fines totaling over $265,000. In addition, individuals involved in the incident paid $15,000 each, served 60 days in home confinement, performed 160 hours of community service and served one year of supervised release (USEPA, 2005). In short, direct approaches may be hazardous in many ways!

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The good news is that many wild bird problems in or around poultry houses are caused by pigeons, house sparrows or starlings, NONE of which are covered by these regulations. Yet it is important to remember that poultry producers are involved in FOOD production and any approach used on poultry farms has the potential to harm flock performance as well as produce residues in meat or eggs.

Wild bird control methods may be divided into general categories: active control methods and passive control methods. While active methods are designed to reduce or disperse large populations quickly and passive methods provide long-term management potential, a combination of methods is usually most effective.

General Wild Bird Control Methods

Remember that effective control of wild birds is an art, not a science. "One shot," or "one size fits all" approaches are generally not effective. What eliminates a bird problem on one farm may not work at all on another. In addition, since wild birds survive by adapting to each situation, don't be surprised if your control efforts are only successful for a short time. The secret to solving bird problems is to consistently address the problem and to vary control tactics (US-FWS, 1992). Wild bird control methods may be divided into general categories: active control methods and passive control methods. While active methods are designed to reduce or disperse large populations quickly and passive methods provide long-term management potential, a combination of methods is usually most effective.

Active control methods

Active control methods are those methods that result in reduction or dispersal of the wild bird populations. Effective, active control methods may be divided into five broad classifications: frightening, poisoning, trapping, shooting, and nest destruction (Booth, 1994.

While it is illegal to harm or capture protected bird species, it is not illegal to frighten them. Frightening devices such as bird distress calls, pyrotechnics, flashing lights, whirling shiny items, balloons, hawk or owl figures and a variety of other methods can effectively reduce bird concentrations in a given area. However, it is important not to get in a routine, successful operations depend on timing, persistence, organization and diversity in device used (Berry, 2003; Booth, 1994).

Although effective poisons for nuisance bird species exist, most of these toxicants are restricted use materials and can be toxic to humans. In addition, it is important to remember that use of these poisons means you are liable for the death of any birds consuming the poisons. Therefore, is very important to use poisons prudently and according to label directions.

There are numerous traps and trap designs available from a variety of sources. Most designs are live traps, which allow the user to free everything other than house sparrows, pigeons and starlings. When using traps, it is important to feed birds with the bait for a few days (pre-bait) prior to starting and to check traps often (Booth, 1994).

Shooting is not an effective means of destroying a large number of birds. Yet shooting can be an effective method of eliminating a few individual house sparrows, pigeons or starlings within a relatively small area. However, choosing the right weapon and location for shooting is obviously important (Booth, 1994, Byler, 2002).

Nest destruction can be an extremely effective method of reducing wild bird numbers. However, nests are often constructed in locations that are high above the ground to avoid predators, so nest destruction efforts can become very involved. In addition, nest destruction should be approached with caution since nest materials often contain many thousands of insects (especially mites) and possibly disease causing bacteria or viruses. It is important to avoid spreading these vermin and microbes to you or your flock (Booth, 1994). It is also important to quickly destroy nesting materials following removal to prevent reuse of the materials by other birds.

Passive Control Methods

To survive, all wild animals (including birds) need the following four essential factors: space, food, shelter and water. Effective long-term control of wild birds involves limiting access to as many of these essential factors as possible (Bryan and Pease, 1991).

Space allows wild birds to rest, roost and relax while on the farm. Most birds prefer space that is high and protected from predators such as cats. Use of roosting spots should be discouraged by use of netting, sticky repellants, or "Porcupine wires" (Booth, 1994)

Since pigeons, house sparrows and starlings can feed on a wide variety of materials, it is nearly impossible to completely eliminate food sources on poultry farms. However, eliminate access to as many food sources as possible. Clean up spilled grain or feed. Reduce conditions that lead to multiplication of insects. Avoid planting trees that produce fruits that birds may eat near poultry houses (Bryan and Pease, 1991).

Trees also provide shelter for wild birds. In addition, wild birds will nest in the eaves or other cavities in poultry houses if given the chance. It is important to remove existing nesting materials and to cover or "plug" holes that allow wild birds access into poultry houses.

Water is essential for the survival of all animals. Although it is virtually impossible to limit the access of wild birds to every water source, it is important to ensure that areas around poultry houses are well drained. Standing water can encourage not only wild birds, but insect populations that could provide food or spread diseases (like mosquitoes).

Summary

Since wild birds have been shown to carry numerous diseases, internal parasites and external parasites, control is necessary. However, all avian species except house sparrows, pigeons and starlings are protected by state and federal migratory bird regulations. House sparrows, pigeons and starlings may be controlled by active or passive control methods. Active methods are designed to reduce large populations quickly, while passive methods provide long-term management potential.

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