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Current Report

Oklahoma Cooperative Extension Service • Division of Agricultural Sciences and Natural Resources
Oklahoma State University

Results:
OSU Grain Elevator Dust Emission Study

Conducted by Oklahoma State University
Division of Agricultural Sciences and Natural Resources
in Conjunction with
Oklahoma Grain and Feed Association Task Force and,
Oklahoma Department of Environmental Quality

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Background

The 1990 Clean Air Act required the Oklahoma Department of Environmental Quality to develop permit programs for a variety of industries, including the grain handling industry. This process involves the use of emission factors for grain elevator operations. The emission factors are an integral and important part of the determination of grain elevators' "potential to emit" airborne dust and in the calculation of operating fees. Unless specifically permitted by the state regulatory authority, firms with a potential to emit over 100 tons/year are classified as major source polluters and fall under a lengthy federal EPA permitting process.

The implementation of the permitting process in Oklahoma highlighted an urgent need for accurate emission factors which are representative of typical Oklahoma grain elevators. The only existing source of emission factors for grain elevators is the EPA's AP-42 document. The research study on which the AP-42 estimates are based was conducted in the early 1970's.

Examinations of the research methods used to develop the estimates in the AP-42 document along with the analysis of other available data caused the Oklahoma Grain and Feed Association (OGFA) task force, Oklahoma Department of Environmental Quality (DEQ) representatives, and members of the Oklahoma Air Quality Council (AQC) to become concerned that the existing AP-42 emissions estimates were seriously flawed and overstated. Preliminary estimates indicated that the AP-42 emissions factors could result in the need for over $9 million worth of additional dust control equipment by Oklahoma elevators.

Due to the concern over the existing emission factors and the critical need for accurate data, a team of faculty from the OSU Division of Agricultural Sciences and Natural Resources proposed a grain dust emission study on May 31, 1994. The study was designed to generate accurate, representative, and scientifically defensible emission factors. Subsequently, the text of grain industry subchapter of the Oklahoma Clean Air Act, which was passed on June 14th, 1994, endorsed the concept of the emission study. The grain industry sub-chapter specified that the existing AP-42 emission estimates for receiving and loading would be used as interim values for a period not to exceed one year, during which time a grain dust emission study would be conducted to develop permanent emission factors.

The grain industry sub-chapter was formally passed by the AQC on June 14th, 1994 and subsequently passed by the DEQ Board on September 28, 1994. The final protocol for the test was submitted to the Oklahoma DEQ and AQC by the OSU faculty team on September 16, 1994. The protocol was reviewed by DEQ staff and formally accepted on September 20, 1994. The study was conducted in Alva Oklahoma on September 26-27, 1994.

Study Objectives

The primary objective of the study was to capture and measure the amount of grain dust emitted during typical receiving and load-out processes of a country elevator. The study was designed to determine:

1. Receiving Emissions
2. Load-out Emissions
3. Dump pit dust baffle efficiency
4. Impact of truck type on receiving emissions

Wheeler Brothers' Elevator in Alva, OK was selected as the test site because it was the only elevator identified with an enclosed dump shed and dump pit dust control baffles which were easily removable.

Test Procedures

<u>Overview</u>

The basic format of the receiving and load-out tests involved unloading or loading trucks containing a known amount of grain in a specially modified enclosed dump shed. A 7.5 h.p. centrifugal blower mounted outside the dump shed was used to evacuate the dust laden air from the shed through a set of fabric bag filters. The air movement generated by the centrifugal blower helped to keep all of the airborne particles in suspension until they reached the 13" diameter inlet pipe, positioned near the center of the dump shed, which exhausted to the filter bags. Two additional high volume propeller fans were stationed in the shed (see Figure 1) and operated during the test to simulate a 12-15 m.p.h. wind through the dump shed. These fans helped to further ensure that all of the small, light weight dust particles remained in suspension.

<u>Dump Shed</u>

The enclosed driveway portion of the concrete dump shed in which the test was conducted has a total volume of approximately 24,000 cu. ft. The dump shed had full height driveway doors on the east and west ends. A small office was located to the south of the dump shed area and was separated by a door. A man-lift access area was located along the north of the dump pit.

A temporary plywood partition was constructed to separate the dump pit area from this access area. A 13 inch diameter

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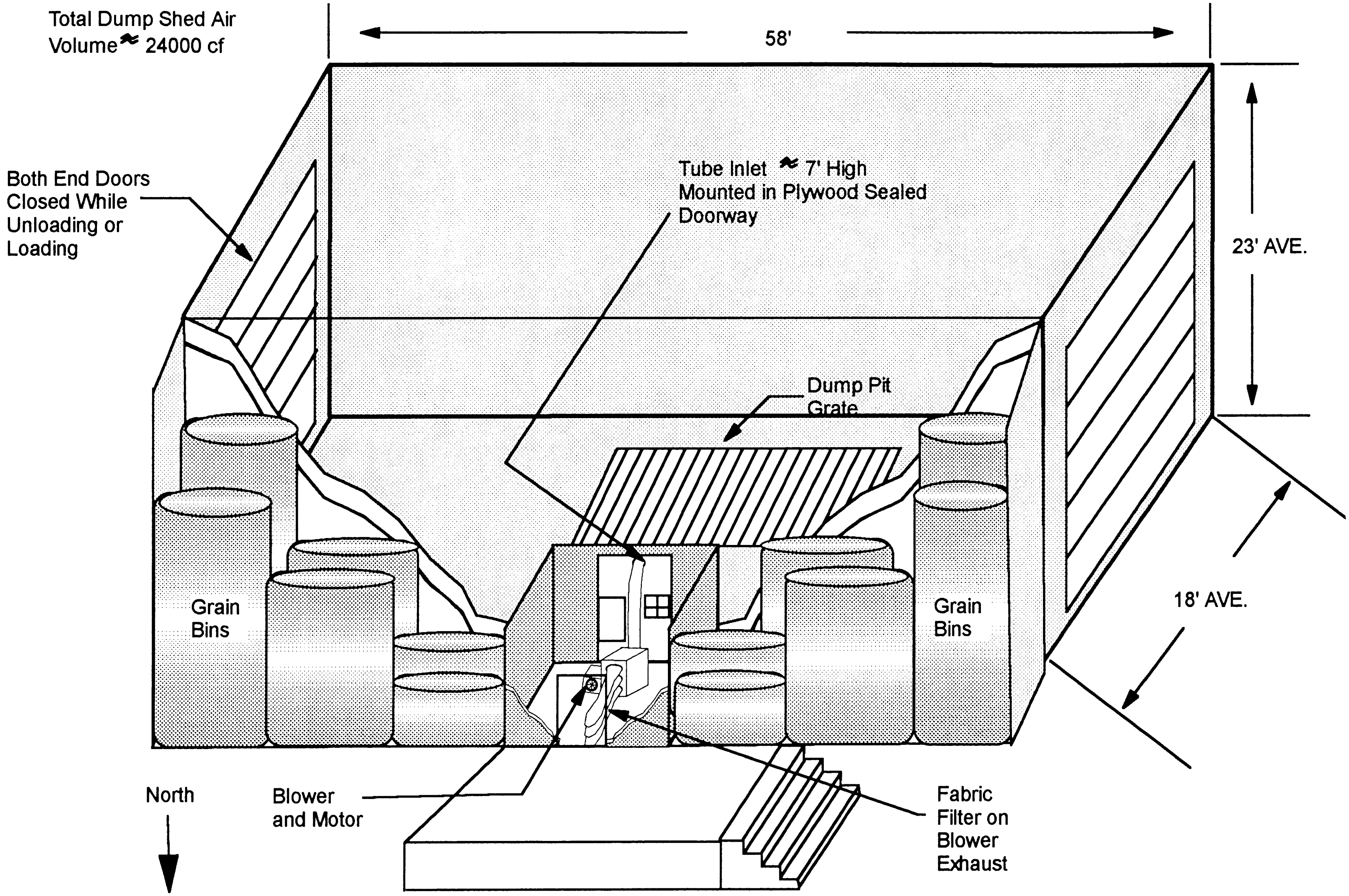
Figure 1. Dump Shed Layout



Predicted Airflow Pattern: Under Dump Shed Doors, Over Pit and Up Into Inlet Tube steel air duct was routed through the plywood partition with the inlet positioned approximately 7' high and directly above the dump pit unloading point. The duct routed the dust laden air from the enclosed driveway area to the centrifugal blower and filter bag assembly which were mounted in the man-lift access area.

All minor cracks between the plywood partition, the ducting, and the concrete walls were sealed with duct tape or other sealing material. The only air inlet into the enclosed driveway area of the shed was the small gaps around the truck doors on the east and west ends of the shed. The negative pressure generated by the 7.5 h.p. blower ensured that no dust escaped from these cracks. The primary air flow was around the doors, across and over the grain dump pit, and up to the outlet duct.

A small door was constructed in the plywood partition to allow the truck driver to exit the dump shed after loading or unloading processes were completed and to allow the test supervisors to monitor the test without disturbing the outer doors. The partition was also equipped with a plexiglass window which allowed test personnel to observe the test without entering the enclosed shed.

Dump-pit

The dump pit grate had a surface area of approximately 64 sq. ft. (8' by 8') and a depth of 12 ft. In order to simulate typical operating conditions the receiving test began with the pit empty and the elevator leg operating before and during the time the grain was being unloaded into the pit. The dump pit was equipped with removable dust control baffles which were designed to partially restrict dust laden air from leaving the dump pit. When all of the baffles were positioned in the fully closed position, approximately 14% of the surface area of the dump grate was open. During the receiving operation the baffles directly under the grain swung open allowing the grain to flow through, and generating additional open area. The dump pit baffles were removed for the initial receiving tests which involved both hopper-bottomed and end-dump trucks and were re-installed for the baffle efficiency test. The dump pit was equipped with a pneumatic dust control system but, this system was not operated during the test procedures.

Blower and Filter Bags

The outlet from the 7.5 h.p. centrifugal blower was attached to three, 6" diameter by 12' long high efficiency fabric bag filters through a specially constructed manifold. The blower provided approximately 2,400-2,500 c.f.m. which allowed for a complete air exchange of the dump shed in approximately 10 minutes. The blower was started when the grain unloading or loading process began and was operated for a sufficient amount of time to create 1 1/2 to 2 air exchanges for the dump shed area. During the test, manometer readings were taken periodically to measure the differential pressure across the blower. These measurements, along with the manufactures fan curve for the blower were used to calculate the actual airflow through the filter bags.

The fabric filter bags and end clamps were weighed before each test to establish a tare weight. The bags were reweighed at the completion of each test to determine the amount (lbs.) of dust captured. After each test was completed and the bags had been weighed, the clamps were removed from the end of the bags and the bags were cleaned by exhausting air from the centrifugal blower through the bags with the ends opened. Periodically during the two day testing period, when the manometer readings indicated that the static pressure readings were increasing, one filter bag was replaced with a new, or hand-cleaned bag, prior to the next test.

Trucks

Two truck types, a hopper-bottomed semi-trailer and an end-dump tandem axle truck, were used during the open dump-pit (baffles removed) receiving test. Each truck had a capacity of approximately 17-18 tons (34,000-36,000 lbs). Five hopper-bottomed loads and five end-dump loads were used for the receiving tests. Ten more end-dump loads were used forthe dump pit dust baffle and load-out tests (five loads for each test).

Load Out Spout

The discharge spout in the dump-shed was of a fixed height design and was approximately 6 ft. above the bottom of the truck bed. The spout was in line with the inlet pipe to the centrifugal blower. Each load-out test took approximately 6 1/2 minutes, indicating an effective load-out speed of 5,700 bu./hr (170.8 tons/hr.).

Table 1
Summary of Emission Test Design

Test Number	Purpose	Truck Type	# Loads	Avg. Load Weight (tons)	Avg. Unloading or loading time	Time of fan run
1	Receiving	End-dump	5	18.15	3.5	20 min
1	Receiving	Hopper bottom	5	17.63	1.5	20 min*
2	Baffle	End-dump	5	18.46	3.5	20 min
3	Load out	End-dump	5	18.50	6.5	20 min

* The first two repetitions for the hopper bottom truck used a fan time of 15 minutes since the dump shed was free of visible dust after that period of time. The fan time for the remainder of the tests were increased to 20 minutes after analysis of the preliminary manometer readings and calculated airflows.

RESULTS

Grain Quality

Each truck load of wheat used for the test was officially sampled and graded by Enid Grain Inspection Service (licensed under the United States Grain Standard Act). Grain grades are a function of a number of variables including test weight (the density of the kernels, lbs/bu.), the percentage of foreign material (FM), shrunken and broken kernels (SB), damaged kernels (DK), and other factors. The grading standards provide lower limits for test weight and upper limits for all of the other factors. Any one grading factor can lower the final grade. For example, a low test weight would lower the final grade, regardless of the FM, SB, DK, and other factors.

Wheat quality is affected by environmental conditions. The quality of wheat received by a particular elevator varies from year to year with the local growing and harvesting conditions.

The amount of dockage in the grain and the moisture content are not grade factors but, are recorded on the official grade sheet. Dockage consists of material either larger than or smaller than the average sized wheat kernel which can be separated by screening procedures. The official grades and relevant grade factors for the test samples are provided in Table 2. The grain used in the test appeared to be representative of hard red winter wheat grown in Oklahoma.

Table 2
Grain Quality Factors-Averages

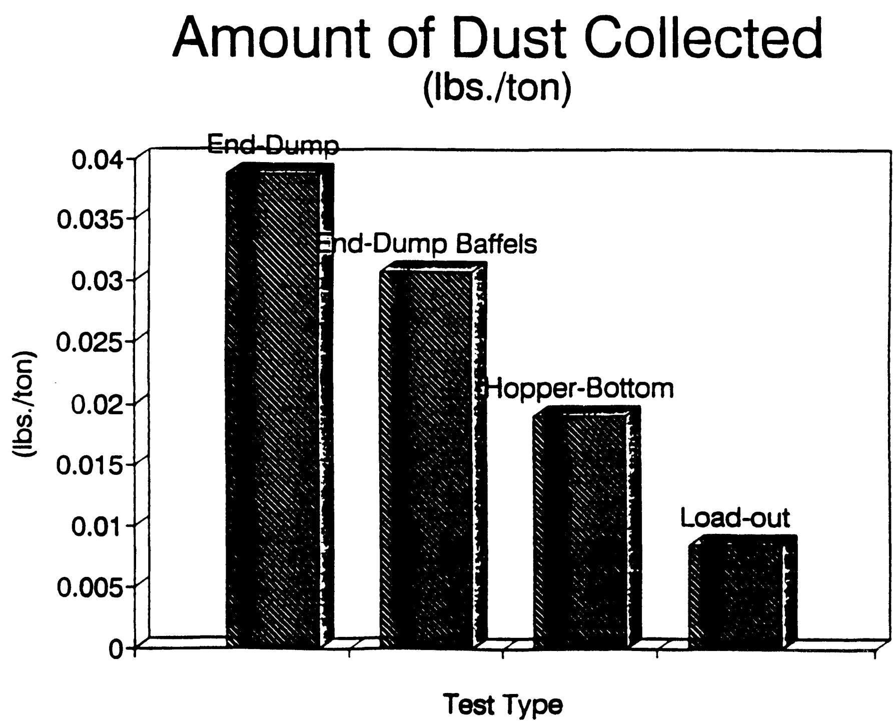
Test	Test weight	Moisture	FM	SB	Dockage	Grade
Receiving-End-dump	60.4	12.1	.1	1.5	.4	1
Receiving-Hopper	60.4	12.0	.1	1.5	.3	1
Baffle	60.4	11.5	0	1.5	.4	1 & 2
Load-out	60.3	12.0	.1	1.7	.5	1 & 2
Overall	**60.4**	**11.9**	**.1**	**1.6**	**.4**	**1 & 2**

Dust Emission Estimates

The calculated dust emissions (amount of dust captured per ton of grain handled) are illustrated below. The average amount of dust collected during the receiving study was .0191 lbs./ton for the hopper bottom truck and .0388 for the end-dump truck for an overall average of .029 lbs./ton. The dust control baffles reduced the amount of dust collected by 20.9%. The amount of dust collected during load-out was .0084 lbs./ton.

Table 3
Summary of Airborne Dust Collected (lbs./ton)

	Receiving Hopper Bottom	Receiving End-dump	Receiving baffles	Load-out
Load 1	.0172	.0308	.0284	.0051
Load 2	.0193	.0273	.033	.0071
Load 3	.0181	.0537	.0308	.0077
Load 4	.0219	.0430	.0305	.0101
Load 5	.0190	.0393	.031	.0122
Average	**.0191**	**.0388**	**.0307**	**.0084**
Receiving-Overall Average	**.029 lbs/ton**			
Baffle Efficiency	20.9%			



The emission data for each test was consistent across the various repetitions. The receiving dump pit baffle test and the hopper bottom tests demonstrated the least load-to-load variations, while the receiving end-dump truck tests had the most variation. The results indicated that the hopper bottom truck had approximately half (49.22%) the dust emissions of the end-dump truck. A comparison of the calculated dust emissions with the existing AP-42 emission factors is provided in Table 4.

Table 4
Comparison of Dust Collected with AP-42 Emission Factors
(lbs./ton)

	Receiving			Loading
	Hopper Bottom	End Dump	Overall	
Dust Collected	.0191	.0388	.029	.0084
AP-42 Emission Factor	.60			.3

Dump Pit Dust Control Baffle Efficiency

The dust control baffles reduced the amount of airborne dust collected by 20.9%.The results of a separate study of non-airborne (settled) dust indicated that the dump pit baffles were more effective in limiting non-airborne dust than in limiting airborne dust. The baffles reduced the amount of dust collected on the floor by over 52%. The overall efficiency of the dump pit baffles in limiting both airborne and non-airborne dust was 39.17%.

More Effective Designs Available

The dump bit baffle design used in this test were installed about 4-5 years ago. They are one of a variety of baffle designs developed by millwrights in the Oklahoma region. More efficient designs are available that are reported to have higher efficiency compared to the baffles tested at this elevator.

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