# WIND BAFFLES FOR TRUCKS

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## INTRODUCTION

Wind action is often the cause of grain loss from trucks when hauling from the field or to the elevator. This loss may be responsible for the spreading of weed seeds and the mixing of varieties which may be imore important than the grain lost.

In many districts covering loads with tarpaulins has not been accepted, for many farmers consider a tarpaulin to be inconvenient to use and to store.

An investigation was carried out to determine if baffles located at the front and sides of a truck box would reduce grain loss due to wind action.

Experimental evidence was considered necessary. To reduce the cost and to provide better control, a model analysis was conducted. A few verification tests were then made with a farm truck.

## LITERATURE REVIEW

Malina (5) listed the mechanical forces acting on a particle in contact with a flowing fluid. Gravitational, fractional, and inertial forces appear to be the most influential in determining the velocity at which the particles will move.

Davis (2) found that before particles are lifted into the stream they are rolled until a small cavity below the particle has its opening upstream. Particles rise into the fluid when the difference between the static pressure below the particle and the static pressure above exceeds the apparent specific weight of the particle.

Hoerner (3) shows the variation in pressure in the vicinity of a solid barrier in an airstream. Pressure on the windward side is above atmospheric while the leeward side is below atmospheric, causing swirling action around the barrier. Porous barriers should reduce this swirling action by increasing the leeward pressure.

## A PREDICTION EQUATION

Modelling should be carried out according to the Froude and Reynolds criteria. However, as Lieu and Albertson (4) point out, the simultaneous fulfillment of these two similitude criteria with the same fluid is impossible. A reduction of the scale requires an increase of velocity for the Reynold criterion and a decrease of velocity for the Froude criterion.

Woodruff and Zingg (6) found that kinematic and dynamic similarity are sufficiently satisfied if; (a) the approaching airstream of model and prototype are similar and (b) the flow about the given object is characterized by a Reynolds number greater than 2.5 x $10^4$.

In the wind tunnel used, the variation of approach velocity with height varried as the power law with an exponent of 0.1; that is, the approach velocity for model and prototype were similar. Exponents for atmospheric conditions can be as low as 0.07; however, Davenport (1) found the average for level terrain to be 0.14.

The Reynolds numbers were greater than 2.5 x $10^4$ for both model and prototype; consequently the prediction equation could be developed from the Froude criterion

$$Fm = Fp$$

$$\frac{Vm}{\sqrt{gLm}} = \frac{Vp}{\sqrt{gLp}}$$

$$\frac{Vp}{Vm} = \frac{\sqrt{Lp}}{\sqrt{Lm}} = \frac{Up}{Um} = \text{constant}$$

for any given system ........... 1

where:

F = Froude number
V, U = Velocity
L = Length dimension
m = Model
p = Prototype

This implies that the ratio of velocities for a test condition must equal the ratio obtained for the standard condition. The standard condition in this case is a truck box level with the cab and filled with grain.

Um, the limiting velocity for the standard model condition was 1200 fpm. As used here the limiting velocity is the velocity at which the kernels begin to move.

Up, the limiting velocity for the standard prototype condition was 34 mph. This was the average of a range of velocities from 31 to 36 mph. These velocities were obtained by testing a prototype on a level, black topped highway when the wind velocity was less than 5 mph.

Substituting and rearranging equation 1 the prediction equation becomes

$$Vp = 0.028\ Vm \quad \text{.......................} \quad 2$$

where Vp is in mph and Vm in fpm.

## APPARATUS AND MATERIAL

### 1. *Wind Tunnel*

A G.M. diesel motor powered the 6 blade 42" diameter axial flow fan which was located downstream from the 42" x 46" x 60" test section.

### 2. *Instruments*

To measure the air velocity in the tunnel a Dwyer #400 Air Velocity Meter was attached to the pitot tube placed to measure the velocity at the level of the top of the model truck cab.

For prototype tests a Dwyer Wind Speed Indicator was attached to the truck box to measure the wind velocity.

### 3. *Baffles*

Four types of baffles were used:

Type I was constructed as a solid vertical wall for the front of the box.

Type II was constructed like a louvre. The members were inclined at various angles to the grain surface and the spacing between boards was varied.

Type III was constructed with a vertical board across the front of the truck, a slot, and an inclined board.

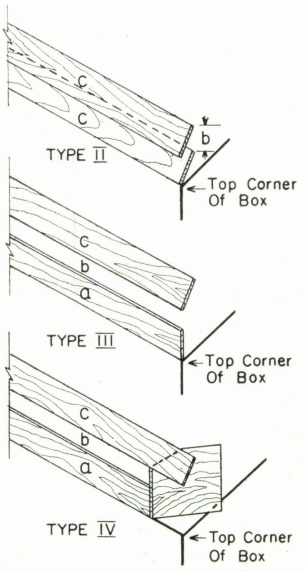

Figure 1. Experimental Baffles.

Type IV was similar to Type III. The bottom board of Type III was shortened and wings added at 45° to the box sides.

a) *Front Baffle*

The inclined members are at 45° to the top of the box and the wings are at 45° to the side of the box.

In all cases the inclined members were the equivalent of 8 feet in length. For the two baffles with wings the vertical member was shortened until the wings protruded 3 or 4 inches beyond the side of the box.

b) *Side Baffle*

All side baffles were vertical and were the length of the box. Tailgates the same height as the side baffle were used.

c) *Truck Box*

Two truck boxes were used. The high box was 7'8" x 14'4" x 3'8" and the top was level with the truck cab top. The low box was 7'88 x 14'4" x 2'6" and the top was 1'2" below the truck cab top.

4. *Scale Factors*

A scale of 5/8" = 1' was selected. This was satisfactory since the projected area of the model was approximately 8% of the cross-sectional area of the tunnel test section.

Wheat with a specific weight of 48 lbs. per cu. ft. and an equivalent diameter of 0.145" was used in the prototype. An equivalent diameter as used here is the diameter of an equal volume of spheres.

For convenience, sand which passed through a 0.0232" opening and was retained on a 0.0165" opening was used as the model material. This sand with a specific weight of 89 lbs. per cu. ft. was considered to have an average diameter of 0.0198", the average of the screen openings.

A distorted model resulted since the scale factor for the baffles was 19.2 and for the granular material 7.3.

## TEST PROCEDURE

The following are the steps followed for testing.

1) the truck box was filled with sand, then levelled

2) the appropriate baffle was placed on the box

3) the unit was positioned in the tunnel
    (a) facing the direction from which the air flows
    (b) at 30° to the direction from which the air flows

## TABLE I
## FRONT BAFFLE DIMENSIONS

| Baffle Number | Baffle Type | Equivalent Height in Inches a | b | c | Equivalent Wing Dimensions in Inches |
|---|---|---|---|---|---|
| 1 | I | 24 | | | |
| 4 | II | | 8 | 12 | |
| 3 | III | 8 | 6 | 10 | |
| 10 | IV | 14 | 6 | 10 | 24 x 24 |
| 16 | IV | 7 | 7 | 7 | 16 x 16 |

a—Vertical Board, b—Slot, c—Inclined Board.

## TABLE II
## SIDE BAFFLE DIMENSIONS

| Baffle Number | Lower Vertical Member in Ins. | Slot in Inches | Upper Vertical Member |
|---|---|---|---|
| d | 10 | 4 | 6 |
| e | 8 | | |
| f | 14 | | |

## TABLE III
## WIND TUNNEL RESULTS – HIGH BOX MODEL

| Front Baffle | Side Baffle | Direction of Wind (degree) | Limiting Velocity Vm fpm | Vp mph | Equivalent Forward Speed (mph) | Equivalent Cross-ward Speed (mph) |
|---|---|---|---|---|---|---|
| None | None | 0 | 1200 | | | |
| 1 | | 0 | 1600 | 45 | | |
| 1 | | 30 | 1400 | 39 | 34 | 20 |
| 4 | | 0 | 1850 | 52 | | |
| 4 | | 30 | 1375 | 38 | 33 | 19 |
| 10 | | 0 | 1850 | 52 | | |
| 10 | | 30 | 1750 | 49 | 42 | 24 |
| 16 | | 0 | 1925 | 54 | | |
| 16 | | 30 | 1575 | 44 | 38 | 22 |
| 16 | d | 0 | 2200 | 62 | | |
| 16 | d | 30 | 1650 | 46 | 40 | 23 |
| 16 | e | 0 | 2250 | 63 | | |
| 16 | e | 30 | 1700 | 48 | 42 | 24 |

4) the motor was started and the speed increased until the sand could be seen to move

5) the mean free stream velocity was recorded

## VERIFICATION TEST

Baffle No. 16 was placed on the prototype used to determine Up (see figure 2). An average velocity of 65 mph was found to be the limiting forward speed.

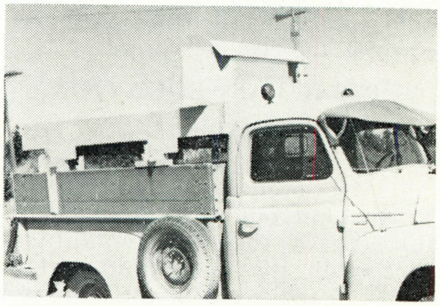

**Figure 2.** Verification Test Truck and Box.

## DISCUSSION

From model tests baffle No. 16 was found to be the most effective in protecting the grain surface. When this baffle was prototype tested the limiting speed was found to be higher than the speed calculated with the prediction equation by approximately 20 *percent*. Modelling was considered satisfactory, for the model result was conservative and 20 percent was not considered excessive since there are a number of variables which could not be completely controlled.

Side baffles did not greatly improve the performance of baffle No. 10 or No. 16. For the other baffles the use of side baffles increased the limiting velocity as much as 17 mph.

Type 4 baffles were the most effective. Any slotted baffle approximately 30 percent porous and solid for the first 6 inches above the box will protect the grain surface against fairly high headwinds. Protection from cross winds is not easily obtained. Side baffles are not completely satisfactory although their use is almost the same as leaving the box unfilled.

These results cannot be extrapolated to include grains other than wheat unless further testing is carried out. Baffles which are effective for wheat will undoubtedly be effective for other grains also, but the limiting velocities have not been determined.

## CONCLUSIONS

1. A wind tunnel can be used to test the effectiveness of wind baffles for trucks. Model theory and fluid flow theory must be carefully followed for satisfactory results.
2. A simple baffle, constructed from $5.00 worth of material, will permit air velocities of at least 60 mph without loss of wheat. The identical truck without baffle lost wheat when air velocities exceeded 35 mph. This baffle was also satisfactory for a forward velocity of 40 mph and a cross wind of 25 mph.
3. Considerably more elaborate baffles are necessary to protect against cross winds in excess of 25 mph.

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## ACKNOWLEDGEMENT

The assistance of Prof. D. M. Gray with the theory of model analysis is gratefully acknowledged.

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Continued from page 13

from under the cover and air turbulance effects over the uncovered portion of the plate due to the thickness of the cover would affect the calibration.

## USE OF THE GAUGE

Assuming that a gauge, with three calibrated scales mounted on the reservoir and three calibrated rain gauge funnels supplied, is to be used to schedule irrigation for a crop of oats during the growing season, the following procedure should be followed.

1. The field capacity and permanent wilting point of several soil samples should be determined or estimated. Because the soil with the greatest sand content will have the lowest water-holding capacity, this soil should be used as a basis for computing the end points on the three calibrated scales. The scales should have a permanent wilting point mark put on each of them at a distance below the spout, which is at the field capacity point, equal to the water-holding capacity of the soil with the most sand.

2. The day the crop emerges, the actual moisture in the soil with the most sand should be determined and the corresponding water level placed in the irrigation gauge according to the scale to be used for the first ten inches of crop growth. The largest rain gauge funnel should then be placed on the gauge. The gauge is then ready to indicate soil moisture deficit during the first ten inches of crop growth.

3. Whenever the gauge indicates that approximately two-thirds of the effective water-holding capacity of the soil has been depleted, the moisture deficit as shown on the gauge should be replaced in the soil with irrigation water and in the gauge with distilled water.

4. When the crop reaches ten inches in height, the water level in the reservoir must be changed so that it indicates the same soil moisture deficit on the scale to be used during the ten to sixteen inch period of crop growth as it did in the first scale. The rain gauge funnel for this stage of crop growth should then replace the first one. The gauge is then ready to function for this growth stage.

5. Similarly, when the crop reaches sixteen inches in height, the water level must again be adjusted to suit the third scale and the smallest rain gauge funnel must be placed on the reservoir.

The gauge, if used as described above, should indicate soil moisture deficit for a crop of oats within an inch of the actual soil moisture deficit on the basis of the tests conducted in 1960.

## CONCLUSIONS

It has been shown that a calibrated irrigation gauge used to schedule irrigation will indicate soil moisture deficit within one inch of water of the actual. The gauge has several advantages over existing methods used to schedule irrigation. One advantage is that it is relatively cheap. The gauge could be produced commercially for approximately thirty dollars. This means that in an irrigated area many gauges could be used and local differences in climatic conditions would be taken into account by the gauges, thus reducing land damage and increasing production.

Also, the gauge will indicate soil moisture deficit from the field capacity level to the permanent wilting point level. Another advantage is the fact that once the gauge is placed in operation in the spring of the year, it requires very little maintenance and indicates directly the soil moisture deficit at any time.

Continued on page 47

Continued from page 38

4. Table IV shows the percentage aphid population on the sprayed and unsprayed plots before and after each spraying.
   The figures indicate that good aphid control was maintained on the sprayed plots.

5. As seen in tables III and IV spray coverage and aphid control was as good or better when the same active chemical ingredient was spread in 55 gallons of water as when spread in 100 gallons. This is an encouraging result and indicates that through the use of properly designed equipment it is possible to reduce the amounts of water used as a carrying agent. This, in turn, makes for a much more efficient operation.

6. Yield data in Table V shows an increased yield on plots that were properly sprayed. Data was collected from one row of each replicates for the three treatments used. Higher yield is attributed mainly to the effective control of leafroll and late blight diseases.

### TABLE IV
### RELATIVE APHID POPULATION

| Date | 55 pga plot | 100 gpa plot | Check Plot |
|---|---|---|---|
| June 30, 1961 | 17.5% | 12.5% | 27.5% |
| July 3, 1961 | 2.5% | 5.0% | 17.5% |
| July 10, 1961 | 12.5% | 5.0% | 12.5% |
| July 11, 1961 | 0.0% | 0.0% | 22.5% |
| July 20, 1961 | 22.5% | 15.0% | 40.0% |
| July 21, 1961 | 2.5% | 2.5% | 32.5% |
| Aug. 1, 1961 | 2.5% | 2.5% | 7.5% |
| Aug. 2, 1961 | 0.0% | 0.0% | 12.5% |
| Aug. 14, 1961 | 17.5% | 20.0% | 40.0% |
| Aug. 15, 1961 | 0.0% | 2.5% | 32.5% |

### TABLE V
### POTATO YIELD

| | Plots Sprayed at 55 gpa | Plots Sprayed at 100 gpa | Check Plots |
|---|---|---|---|
| Saleable | 644 lbs. | 743 lbs. | 559 lb.s |
| Culls | 202 lbs. | 131 lbs. | 125 lbs. |

Note: Sample weights equivalent to yield from 450 ft. of plot row.

7. Fabricated wheel guards were effective in reducing foliage damage until the end of July. The plants at this stage were about 75 percent fallen over. By the first week in August the plants had completely fallen over and become a tangled lattice work. In this stage of growth the wheel guards were unable to separate the vines effectively. Further work in this regard will be required.

## SUMMARY

To obtain full benefits from the use of chemical insecticides and fungicides for controlling insects and diseases in potato crops, proper application with good spray equipment is essential.

Through several years of testing it has been found that tractor-mounted spray rigs, equipped with booms specifically designed for the job, are the most effective. The spray boom that appears most suitable consists of a horizontal cross boom with attached pendants that drop between each row. Two double swivel-type fan nozzles are fitted onto the pendant, one at a point 8 inches below the cross boom, and the other at the bottom. These nozzles force spray to the sides and bottom of the plant and a fifth nozzle clamped to the cross boom between each pendant forces spray onto the top of the plant. To maintain uniform spray pattern throughout the plant canopy, fan nozzle tips should be graduated so that the largest tips are used on the bottom of the pendants, medium size on the sides and the smallest on the overhead nozzle.

Tests to date indicate that by using well designed spray equipment much less water per acre is required to spread chemical insecticides and fungicides.

Further work is required to find ways of reducing variables encountered, so that one year's data can be compared directly to another. Further work is also required to improve the effectiveness of tractor wheel guards in reducing foliage damage.

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Continued from page 41

It should be noted that the gauge does not allow for surface runoff due to periods of heavy precipitation. Whenever the precipitation rate is greater than the infiltration rate of water into the soil, the runoff would have to be estimated and a correction applied to the water level in the reservoir of the gauge.

Also, the gauge will not indicate the correct soil moisture deficit if the soil moisture is allowed to remain at the permanent wilting level for any appreciable length of time.

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Complete details of the work described in this paper can be found in the Master's Thesis, "Development of an Irrigation Gauge", E. E. Brooks, 1961, available at the University of Saskatchewan.