FARM BULK FERTILIZER STORAGE TESTS

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INTRODUCTION

Production and use of granular fertilizers has increased dramatically during the past decade. Sales in Western Canada have increased from about 55,000 tons annually in 1955 to more than 800,000 tons in 1967 (1). This total production was from six plants (there are presently seven). Only two plants manufactured fertilizer in 1955.

Two problem areas have resulted from the increase in fertilizer sales. Firstly, the fertilizer industry has found difficulty in handling and distributing the great quanitities of fertilizer, especially when a large portion of this volume is required during the spring of the year. Secondly, some obvious limitations to bagged fertilizer have become evident with increased application rate.

Handling fertilizer in bulk would increase the efficiency on many farms. If this bulk product were taken from the manufacturing plant during the off-season, their storage and distribution difficulties in the spring would be reduced. The problem then is to design economical farm storage bins or buildings that can keep bulk fertilizer in good condition for several months.

Inquiries regarding the storage of bulk fertilizer could not be answered satisfactorily by either knowledge or experience. A brief literature review failed to yield any desired information. Britton[a] reported a similar lack of information on bin pressures and storage characteristics of fertilizer.

Faced with this serious lack of information and continued requests for ideas and information on bulk fertilizer storage, some effort in the area appeared justified.

[a] Britton, M.G. 1967. Fertilizer storage – what do we really know? A.S.A.E. Annual Meeting Paper No. 67-428, Saskatoon, Saskatchewan.

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BULK STORAGE TEST

Several alternatives were considered before a practical test simulating on-farm conditions was set up with a local fertilizer manufacturer supplying space, fertilizer, and personnel. Local companies, building dealers and suppliers, and farm cooperatives building or marketing a grain or feed bin, were invited to participate in the test by supplying bins.

A wide variety of bin types and designs were included in the test (Table I and Figure 1). Most of the bins were structurally modified by the suppliers on the assumption that fertilizer pressures would exceed those of grain in proportion to densities. Fertilizer density is 58 lb/ft^3 (0.93g/cc) and wheat density is 48 lb/ft^3 (0.77g/cc).

The bins are filled with fertilizer (11-48-0, 34-0-0, 23-23-0, 46-0-0) during the late winter and early spring of 1967. The bins were emptied during early June of that year. They were refilled in the fall of 1967 for the winter storage period. Bins were again unloaded in the spring of 1968.

Following the first storage period (March 1967–June 1967) modifications and improvements were made on the bins to improve storage conditions.

Observations were made during storage and the loading and unloading operations. Specifically, observations related to performance were undertaken in the following areas: (1) Weather protection; (2) Moisture resistance; (3) Corrosion resistance; (4) Structural stability; (5) Ease of emptying and filling.

Bin Structure and Weatherproofing

Bins designed to hold fertilizer must be of sufficient strength to withhold the pressures exerted by the fertilizer. Since fertilizer is heavier than grains and assuming that fertilizer acts in a similar fashion as grain, bins designed for grain are not strong enough for fertilizer. This assumption was upheld during the test. Although no complete failures occurred, single skin

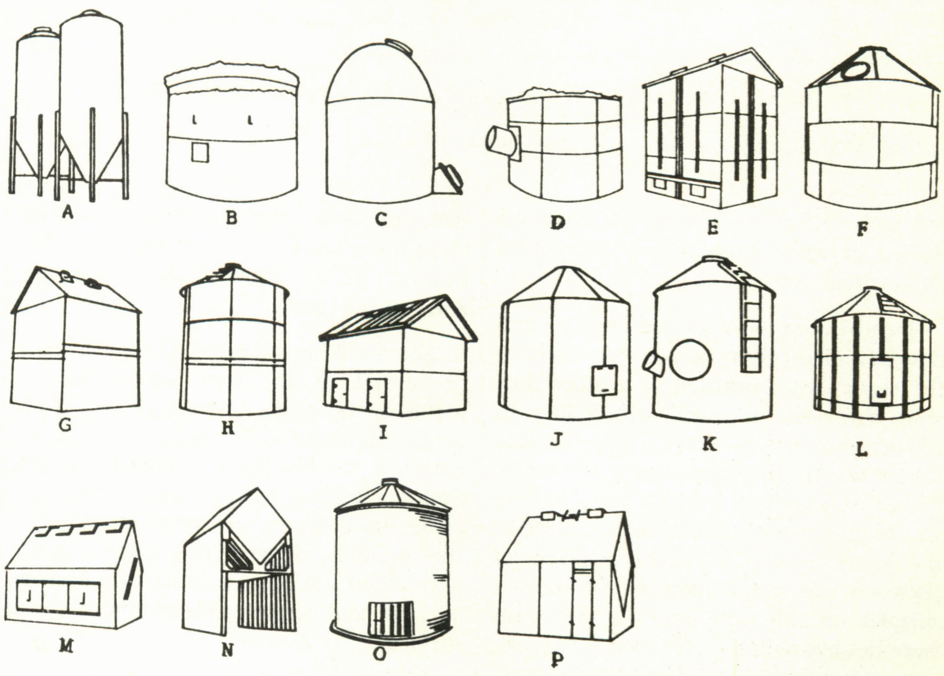

Figure 1. Sketches of bins included in the test.

TABLE I – CAPACITY, COST AND DESCRIPTION OF TEST BINS

Bin	Approximate Capacity Tons*	Cost/Ton**	Description
A	10	$45	Circular, hopper bottomed, coated metal bin.
B	17.7	$10	Double polythene supported by wire mesh frame.
C	10	$50	Circular, one piece, fibreglass bin partially buried in the ground.
D	12.9	$19-$23	Butyl rubber bag suspended on a wire mesh frame.
E	27.8	$23	Four compartment, hopper bottom bin, tongue and grove plywood construction.
F	15	NA	Circular, flat bottomed, sectional, fibreglass bin.
G	29.9	$20	Four compartment, partially hoppered bin. Double wall plywood construction.
H	12.4	$37	Circular, double walled plywood bin with hopper bottom.
I	29	$15	Rectangular plywood granary divided into four bins. Double wall construction.
J	18.8	$21	Double skinned circular plywood bin with flat bottom.
K	13.8	$28	Circular flat bottomed fibreglass bin.
L	24.8	$15	Circular, flat bottomed bin. Double skin construction.
M	40	$24	Four compartment, hopper bottomed plywood bin.
N	28.9	$27	Diamond shaped, overhead, four unit plywood bin.
O	24.1	$30	Circular, flat bottomed, stainless steel bin.
P	20	$35	Double walled, diamond shaped, plywood bin. Two or four compartments.

* Capacity based on average of 58 pounds per foot^3

** Costs based on 1967 quotations

3/8 inch (9.5 mm) Douglas Fir plywood bulged between studs at 12 inch (30.5 cm) centers.

Double skin plywood walls, and double-walled (plywood on both sides of the studs) walls resulted in a more durable bin. Less fertilizer caked due to reduced moisture entry. Considerable caking was initially observed with bins G, I, and N where single ply construction was used. Much of this caking occurred at the joints. In bin M, where single layer plywood was supplemented with asphalt shingles on the roof and the end walls were double-walled (after modifications), observed caking of ferilizer was minimal.

Single skin metal or fibreglass construction was relatively free of caked fertilizer when joints were weather tight. Bins A, F, O, allowed some moisture entry at the joints.

Some caking occurred along the walls of several of the bins constructed of metal or fibreglass (Bins C, F, K). This caking appeared to be caused by moisture entering the bin from various areas and then condensing on the cooler surfaces or areas. Bin C, which was partially buried in the ground, showed this quite clearly with slight caking occurring in a narrow area at and slightly below the ground surface.

Caking along the walls of the two collapsible bins (B and D) was very evident during the first stage of the test. This caking was not due to moisture but heat as a "recrystallization" or "sugaring" of the stored ammonium nitrate occurred. This recrystallization was due to temperature fluctuations around 90°F (32.2°C). Both bins B and D were made using a dark colored material (black plastic and butyl rubber). Clear polyethylene was substituted for the black plastic and a double layer of clear polyethylene was inserted between the butyl rubber and wire cage prior to second filling. No further recrystallization occurred in these bins.

Little problem was evident with the roofs of the fertilizer bins. All adequately shed rain and snow. Caking due to recrystallization occurred in bin N due to a dark roof color and fertilizer piled against the roof surface. The solution to this difficulty would again be a change of roof color or roof design.

Caking occurred on many of the bins due to inadequate sealing of the eaves. Eave areas on the north and west side had more caking indicating wind driven rain or snow was responsible for the moisture entry.

Normal construction consisting of blocking fitted between rafters, must be supplemented with weather stripping, caulking or other forms of sealing to insure satisfactory storage conditions.

It is difficult to assess floors of bins since many of the bins came into the test without floors and were placed on portable platforms. Caking was evident at the base of many bins as moisture entered between the wall and floor.

The most serious caking in virtually all bins was around top hatches, auger chutes and manholes. In all cases moisture entry was due to improper or inadequate sealing, lack of weather stripping, or poor design.

Modifications were made to the various bin openings prior to second filling. Drip ledges or battens that covered the exposed top edge of auger chutes decreased water entry. Placing a small polyethylene sheet 3 or 4 ft (0.9 or 1.2 m) square over the inside of the auger chute before filling was extremely successful in preventing fertilizer caking. Top hatches and/or manholes were a little more difficult to seal; however, polyethylene sheets, weather stripping and clamp down hatches were reasonably successful.