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Evaluation Report 218

Friggstad PA1-40 Pneumatic Applicator

A Co-operative Program Between
ALBERTA FARM MACHINERY RESEARCH CENTRE
PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

FRIGGSTAD PA1-40 PNEUMATIC APPLICATOR

MANUFACTURER AND DISTRIBUTOR:

Friggstad Manufacturing Ltd.
P.O. Box 150
Frontier, Saskatchewan
S0N 0W0

RETAIL PRICE: (January, 1981, f.o.b. Lethbridge)

a. Friggstad PA1-40 pneumatic applicator complete with seed boots and distribution system to feed 35 shanks, with electronic seed monitor and optional electric shut-off $21,258.00
b. Friggstad B3-31, 10.7 m (35 ft) heavy duty cultivator complete with optional three row mounted harrows $13,272.00
c. Friggstad H3-40 packer drawbar complete with seven sections of Inland spiral packers $5,150.00

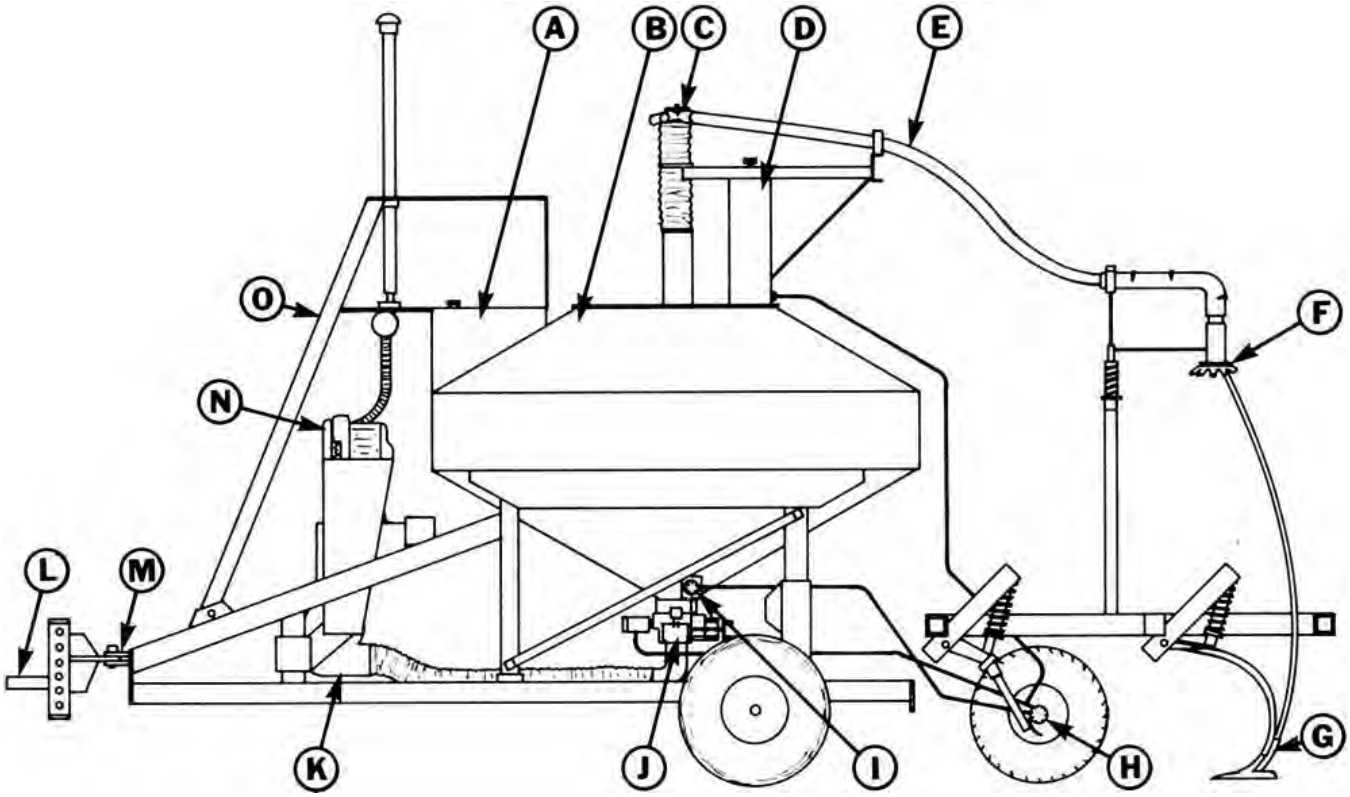

FIGURE 1. Friggstad PA1-40 Pneumatic Applicator: (A) Fuel Tank, (B) Tank, (C) Primary Header, (D) Hydraulic Oil Reservoir, (E) Primary Hose, (F) Secondary Header, (G) Seed Boot, (H) Meter Drive, (I) Tank Agitator, (J) Metering System, (K) Fan, (L) Cultivator Hitch, (M) Applicator Hitch, (N) Fan Engine, (0) Ladder.

SUMMARY AND CONCLUSIONS

Overall functional performance of the Friggstad PA1-40 pneumatic applicator was very good in all seeding conditions. Performance was good when banding fertilizer. When operated with the 10.7 m (35 ft) Friggstad B3-31 heavy duty cultivator. The Friggstad PA1-40 was suitable for seeding both in primary and secondary eld conditions. The Friggstad was also suitable for banding fertilizer at application rates up to 200 kg/ha (180 lb/ac). At rates above 200 kg/ha (180 lb/ac) a signi cant amount of fertilizer escaped from the metering system and dropped on the ground.

Seed placement was good in most conditions. Variation in seed depth was slightly higher than with a conventional hoe drill when measured in the same elds under the same seeding conditions. Seed band width behind each seed boot was always wide enough to provide ample stubble for good windrow support. Maintaining good cultivator frame levelling and ensuring a seeding depth of at least 50 mm (2 in) were critical in ensuring good emergence.

The manufacturer's metering system calibrations were fairly accurate i n wheat, barley, oats, rapeseed and fertilizer on the course meter settings. The manufacturer's calibration for rapeseed indicated only from 50 to 60% of the actual seeding rate when used on the " ne" meter settings. The Friggstad PA1-40 gave acceptable uniform seed distribution across the seeding width in wheat, barley, oats and rapeseed at normal application rates. To accommodate the 35 outlet requirement of the 10.7 m (35 ft) Friggstad B3-31 heavy duty cultivator, one port on each of the ve secondary distribution headers was blocked. Signi cant improvements in distribution occurred when all eight ports were used on each secondary header.

Level of material in the tanks, eld slope, eld bounce and ground speed variation had little effect on metering.

Seeding rate was easily adjusted. Tank and meter cleanout was convenient. Tank lling required the use of a drill ll or auger. Four grease ttings on the applicator required dally greasing.

The Friggstad PA1-40 with B3-31 heavy duty cultivator and H340 packer drawbar could be placed in transport position in less than ve minutes. Transport on paved roads required a separate means of packer transport to prevent packer and road damage.

Rate of work usually ranged from 8.6 to 10.7 ha/hr (21 to 27 ac/hr). About 45 ha (110 ac) could be seeded before re lling both tanks when seeding wheat at a normal seeding rate.

Tractor size depended on soil conditions, seeding depth, cultivator width and soil nishing attachments. In light primary tillage, at a 75 mm (3 in) depth and 8 km/h (5 mph), a 119 kW (160 hp) tractor was needed to operate the applicator-cultivator-packer combination. In heavy primary tillage, at the same depth and speed, a 139 kW (185 hp) tractor was needed.

The centre frame cultivator tires were slightly overloaded in transport. Care had to be exercised when using the tank access ladder.

The operator's manual contained useful information on safety, adjustments, maintenance and operation. A detailed parts list was also included.

Only minor mechanical problems occurred during evaluation.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifying the tank ll access ladder to include a safety handrail as well as an access platform at the base of the steps.

2. Modifying the metering system to reduce fertilizer losses at application rates above 200 kg/ha (180 lb/ac).
3. Supplying meter calibration in SI units.
4. Supplying a spillage tray under the fan engine to facilitate convenient engine oil draining.
5. Supplying secondary headers with correct outlet numbers to suit various cultivator widths without having to block secondary header ports.
6. Supplying a suitable land area meter.
7. Modifying packer drawbar wing castor brackets to prevent bracket twisting and resultant interference.
8. Improving the calibration, accuracy for rapeseed at the ne meter setting.
9. Providing a slow moving vehicle sign as standard equipment.

Chief Engineer: E. O. Nyborg
Senior Engineer: E. H. Wiens
Project Engineer: R. K. Allam

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. The model AF-1 "Air Force" seeder, which now replaces the PA1-40, is equipped with an access platform at the base of the ladder. The top platform of the ladder is equipped with safety hand rails but no provision has been made for hand rails on the vertical portion of the ladder. The engine has been moved to eliminate the possibility of the operator's hand touching the muf er when climbing the ladder.
2. The metering device on all 1981 models has been completely redesigned. The new system incorporates a pressurized tank and an air tight metering device which eliminates any loss of fertilizer or seed at high application rates.
3. Because of the meter redesign on the 1981 model "Air Force" seeders, we have adopted an in-house measurement for calibration, which is based on the SI unit of measure.
4. The engine has been relocated on all new models, allowing unobstructed ow of engine oil into a pan or pail.
5. For inventory and cost reasons, it is not feasible at this time to offer secondary headers to suit every width of chisel plow on the market. As market demand grows, it may become feasible to offer a wider variety of sizes.
6. All 1981 models will be equipped with an acre meter.
7. The wing castors, on the 1981 packer drawbars will be modi ed to prevent the twisting and interference problems experienced.
8. Calibration rates for the ne meter settings will be reviewed and corrections made as required to bring the accuracy to accepted standards.
9. A slow moving vehicle sign will be provided as standard equipment.

NOTE: This report has been prepared using SI units of measurement.
A conversion table is given in APPENDIX III.

GENERAL DESCRIPTION

The Friggstad PA1-40 is a pneumatic seed and fertilizer applicator designed for use with several models of Friggstad heavy duty cultivators. It attaches between the front cultivator hitch members and is supported with dual castor wheels at the rear and a pinned connection at the cultivator hitch point. Seed and fertilizer are pneumatically distributed from two tanks, through a network of tubes, to seed boots attached to the rear of each cultivator shank. It can be used for seeding, for combined seed and fertilizer application and for fertilizer banding.

Seed and fertilizer are metered through two adjustable uted rolls mounted below the tanks, while an air-cooled diesel engine powered fan, forces the metered material through the distribution system. The distribution system consists of a ve-port primary header mounted on the applicator, feeding a series of eight-port secondary headers mounted on the cultivator. Tubes from the secondary headers connect to the seed boots.

The test machine was used with a Friggstad B3-31 heavy duty cultivator. This cultivator was 10.7 m (35 ft) wide with a 4.6 m (15 ft) centre frame and two, 3 m (10 ft) wing sections. It was equipped with 35 spring cushioned shanks, spaced at 305 mm (12 in), arranged in three rows. One port on each of ve secondary distribution headers was blocked to accommodate the number of shanks. The cultivator was equipped with optional three-row mounted harrows and an optional Friggstad model H3-40 packer drawbar with seven sections of Inland spiral packers.

The test machine was also equipped with an electronic monitor and an optional electric meter shut-off.

Detailed speci cations for the pneumatic applicator, cultivator and packer drawbar assembly are given in APPENDIX I while FIGURE 1 shows the location of major components.

SCOPE OF TEST

The Friggstad PA1-40 was operated in the eld conditions shown in TABLE 1 for approximately 132 hours while processing about 800 ha (1980 ac). It was evaluated for quality and rate of work, ease of operation and adjustment, power requirements, safety and suitability of the operator's manual.

TABLE 1. Operating Conditions.

CROP	FIELD TILLAGE CONDITIONS	STONE CONDITIONS	FIELD AREA (ha)	HOURS
Barley on summerfallow	Primary	Occasional stones	130	21
Spring wheat on stubble	Primary	Occasional stones	258	43
Spring wheat on stubble	Primary	Moderately stony	20	4
Spring wheat on summerfallow	Primary	Occasional stones	280	44
Spring wheat on summerfallow	Secondary	Moderately stony	30	5
Rapeseed on summerfallow	Primary	Stone free	2	1
Winter wheat on summerfallow	Secondary	Occasional stones	10	2
Banding fertilizer	Primary	Stone free	70	12
TOTAL			800	132

RESULTS AND DISCUSSION

QUALITY OF WORK

Metering Accuracy: The grain and fertilizer metering system was calibrated in the laboratory[1] and compared with the manufacturer's calibration. Since actual seeding rates for certain settings depended on things such as seed size, density and moisture content, it is not possible for a manufacturer to present charts to include all the varieties of seed. Field calibration checks may be necessary for seed with properties differing from those indicated in the manufacturer's table. Research has, however, shown that small variations in seeding rates will not signi cantly affect grain crop yields.

Calibration curves for wheat, barley, oats and rapeseed are given in FIGURES 2 to 5. At normal seeding rates, actual rates were 9% higher than indicated in wheat and 12% higher than indicated in oats, well within acceptable accuracy limits for these grains. In [1]PAMI

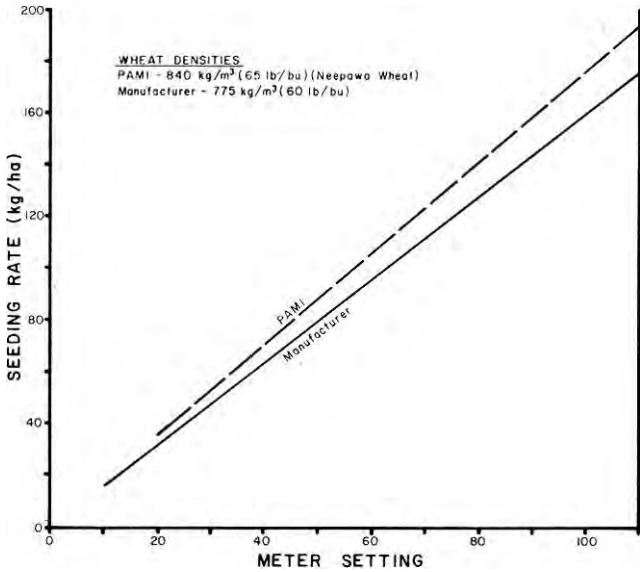

FIGURE 2. Metering Accuracy in Wheat.

[1]PAMI T773, "Detailed Test Procedures for Grain Drills".

barley, at normal seeding rates, the actual rate was 23% higher than the indicated rate.

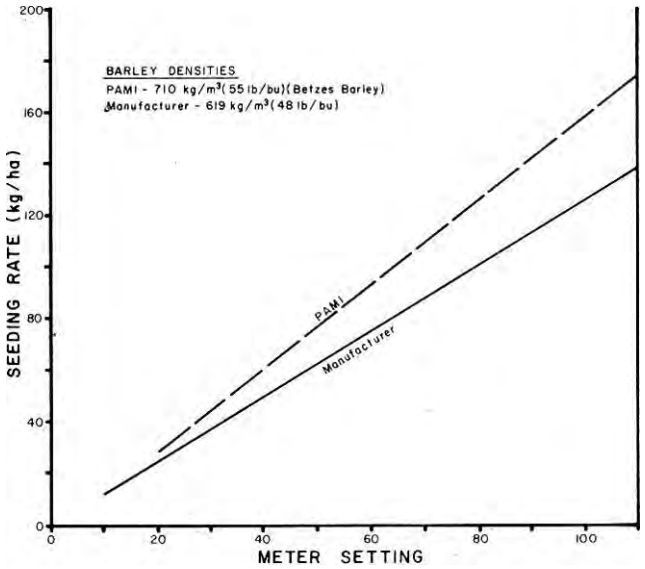

FIGURE 3. Metering Accuracy in Barley.

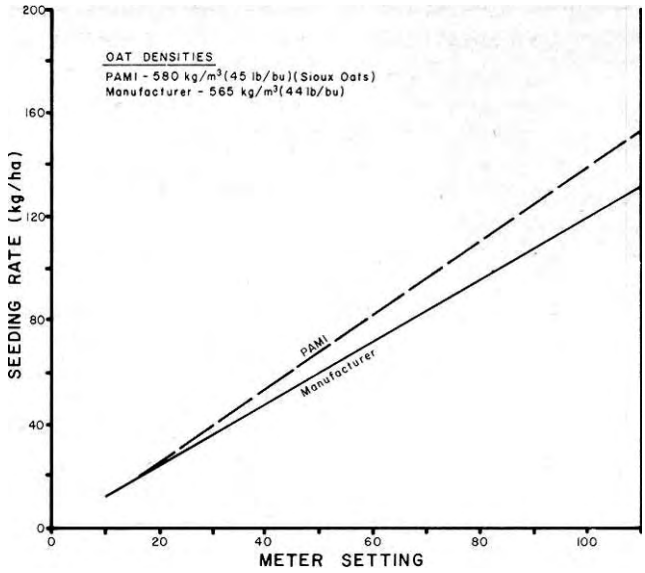

FIGURE 4. Metering Accuracy in Oats.

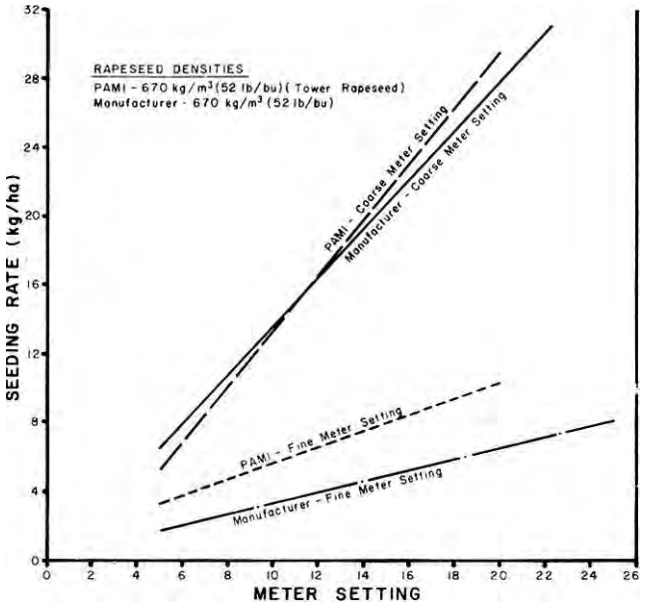

FIGURE 5. Metering Accuracy in Rapeseed.

Two metering ranges were available for small seeds such as rapeseed. The course metering range was the same as used for cereal grains. At a rate of 7 kg/ha (6.2 lb/ac), the actual rate was about 15% lower than the indicated rate. At lower seeding rates, which are often used for rapeseed, the ne meter setting could be used. At a rate of 2 kg/ha (1.8 lb/ac), on the ne meter setting, the actual rate was 90% higher than the indicated rate. It is recommended that the manufacturer consider improving the calibration accuracy for rapeseed at the ne meter setting.

As is shown in FIGURE 6, metering of fertilizer was quite accurate with only a 5% difference between actual and indicated rates.

The application rate was not signi cantly affected by eld or machine variables. For example, the level of grain or fertilizer in the tanks, forward speed, eld slope and eld roughness all had little affect on application rate. The metering rolls were ground driven. As is common with ground driven equipment, drive wheel slip in very soft elds caused a decrease in application rate of about 4%.

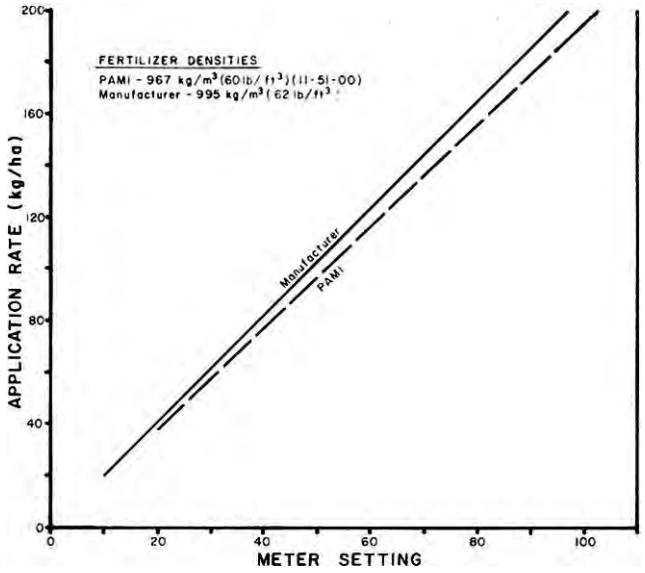

FIGURE 6. Metering Accuracy in Fertilizer.

Seed Distribution Uniformity: The pneumatic distribution system, distributed seed quite uniformly from the meter system to the individual shank boots. FIGURE 7 gives seeding distribution uniformity for the Friggstad PA1-40 in wheat, barley and oats. Although distribution uniformity decreased at high seeding rates, at normally accepted seeding rates, distribution was uniform. For example, at a seeding rate of 80 kg/ha (70 lbs/ac), the coef cient of variation[2] (CV) was 11.5% in wheat, 12.5% in barley and 14.5% in oats. Seeding distribution in rapeseed was uniform, with a CV of 10% at all seeding rates.

Seeding uniformity decreased at higher seeding rates due to the increased volume of seed being introduced into the constant volume of air supplied by the fan. Similarly, due to the air supply remaining constant regardless of forward speed or machine width, changes in distribution pattern uniformity could occur at different forward speeds or for different machine widths.

As there were eight ports on each of the ve secondary headers, a total of 40 seed boots could be used with the Friggstad PA1-40. Since, the 10.7 m (35 ft) Friggstad B3-31 had only 35 shanks, one port was blocked on each of the secondary headers to accommodate the 35 shanks. Blocking the secondary headers signi cantly reduced the distribution uniformity. FIGURE 8 shows distribution uniformity in 11-51-0 fertilizer when all eight ports were used on each secondary header, as would be the case with a 40 shank cultivator, and when one port on each secondary header was blocked, as was done with the 35 shank test machine. When one port was blocked on each secondary header, fertilizer distribution was uniform only at application rates below 115 kg/ha (100 lb/ac). At higher application rates, the CV varied from 15 to 18%. When all secondary header ports were used, however, application was very uniform at all application rates with the CV varying from 5 to 7%. It is recommended that the manufacturer consider modi cations, such

as seven-port secondary headers, to reduce the need for blocking unused ports, thereby improving distribution uniformity at high application rates.

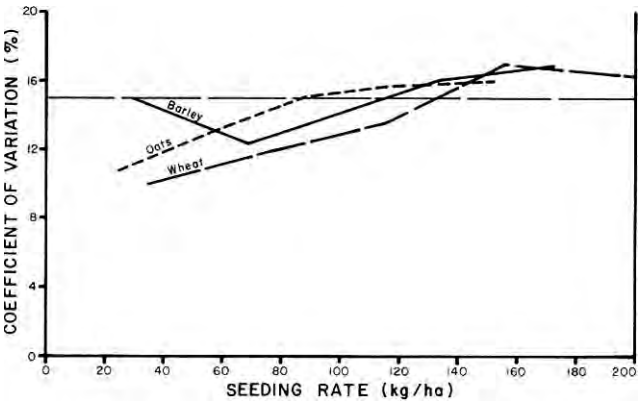

FIGURE 7. Seeding Uniformity in Cereal Grains at 9 km/h (One Outlet on each Secondary Header Blocked).

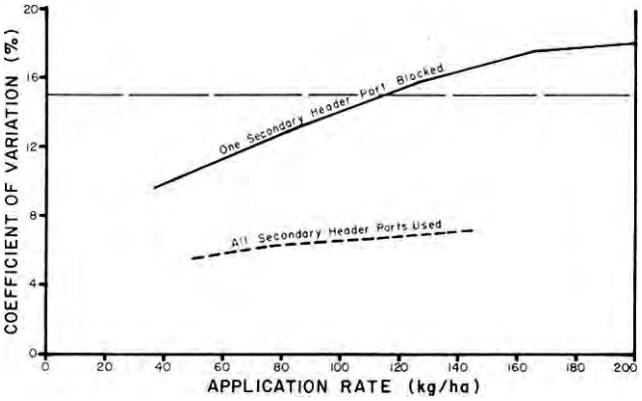

FIGURE 8. Distribution Uniformity in 11-51-0 Fertilizer at 9 km/h.

Grain Damage: Grain damage by the metering and distribution system was well within acceptable limits. For example, in dry Neepawa wheat at 10.5% moisture content, only 0.2% crackage occurred.

Seed Placement: Each seed boot was equipped with a V-shaped de ector (FIGURE 9) to spread the seed behind each cultivator sweep. In most elds, with good growing conditions, the seed was spread wide enough so that it was dif cult to observe distinct rows as the plants emerged (FIGURE 10). Therefore, even with the 305 mm (12 in) cultivator shank spacing, there was suf cient stubble for windrow support at harvest time.

FIGURE 9. Friggstad Seed Boot: (A) V-shaped De ector, (B) Seed Boot, (C) Sweep.

On level and gently rolling elds, vertical seed distribution was quite uniform. Most of the seeds were placed within 18 mm (0.7 in) of the working depth of the bottom of the cultivator sweeps. This compares to a vertical variation of from 12 to 15 mm (0.45 to 0.6 in) for a hoe drill in similar conditions. In elds with sharp hill crests or gullies, seed depth variation became much greater than for a hoe drill, due to the greater distances between shank rows on a heavy duty cultivator than on a hoe drill.

Vertical seed distribution was not adversely affected by eld conditions. The shanks on the Friggstad B3-31 cultivator were suf ciently rigid to maintain a fairly uniform sweep pitch (FIGURE 13), with resultant uniform tillage depth, over a wide range of soil conditions.

Plant Emergence: As with most seeding implements, time and uniformity of plant emergence depended on seedbed preparation, soil moisture and seed placement. The Friggstad was used to seed in a number of elds with different types of seedbed preparation. In all instances, uniform emergence resulted as long as the seed was placed in moist soil and the soil was packed after seeding. FIGURE 10 shows good wheat emergence when wheat was seeded directly into summerfallow as the rst spring operation.

FIGURE 10. Uniform Wheat Emergence (Upper: 35 Days after Seeding, Lower: at Harvest).

Careful cultivator frame levelling was important in obtaining uniform emergence across the cultivator width. Due to the rigidity of heavy duty cultivator frames, improper sideways levelling and fore-and-aft levelling can both result in rows of shanks operating at different depths. FIGURE 11 shows how improper cultivator frame levelling caused streaky barley emergence. Due to dry spring conditions, these streaks were still evident at harvest time.

Seeding Depth: It was very important to seed deep enough to obtain uniform seed coverage. Correct cultivator adjustments for pneumatic seeding were best obtained by comparing the depth of seeds placed by several shanks across the cultivator width and from both the front and rear shank rows. This permitted accurate frame levelling to obtain uniform seed coverage. Seeding shallower than 50 mm (2 in) is not recommended for a heavy duty cultivator, due to poor seed coverage and generally poor cultivator performance at shallow tillage depths.

Frame levelling had to be checked and appropriate depth adjustments made when changing elds, to ensure adequate, uniform seed coverage.

Soil Finishing: All tests were conducted with optional three-row mounted harrows and an optional Friggstad model H3-40 packer drawbar with seven sections of Inland spiral packers. The mounted harrows were effective in smoothing the soil surface and in breaking soil lumps. The harrows also increased weed kill by loosening weeds. Both the harrow force and tine angle were adjustable to suit varying conditions. The packers were effective in compacting the soil and levelling the surface, leaving packer ridges from 20 to 30 mm (0.8 to 1.2 in). FIGURE 12 shows a typical seedbed after rst operation seeding into summerfallow.

[2]The coef cient of variation (CV) is the standard deviation of seeding rates from individual shanks expressed as a per cent of the average seeding rate. An accepted variation for seeding grain or applying fertilizer is a CV value not greater than 15%. If the CV is less than 15%, distribution is acceptably uniform, whereas if the CV is greater than 15%, the variation in application rate among individual shanks is excessive.

FIGURE 11. Streaky Emergence in Barley Caused by Improper Cultivator Frame Levelling (Upper: 45 Days after Seeding, Lower: at Harvest).

FIGURE 12. Typical Seedbed After First Operation Seeding in Summerfallow (Left: Seeded, Right: Unseeded).

Shank Characteristics: The Friggstad B3-31 cultivator was equipped with adjustable, spring cushioned shank holders. During the test, it was used with 405 mm (16 in) wide Edwards sweeps with a 50 degree stem angle, giving a no-load sweep pitch of 2 degrees. These shanks were very suitable for seeding since sweep pitch (FIGURE 13) varied only 2.5 degrees over the full draft range normally expected for a heavy duty cultivator. This resulted in uniform tillage depth and a smooth furrow bottom over a wide range of soil conditions.

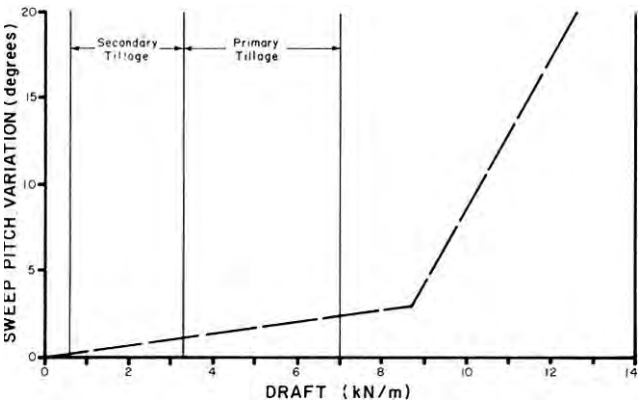

FIGURE 13. Sweep Pitch Variation over a Normal Range of Draft (305 mm Shank Spacing).

Cushioning spring preload was exceeded at drafts greater than 8.8 kN/m (600 lb/ft), occurring well beyond the normal draft range, indicating that the Friggstad B3-31 was suited for heavy primary tillage.

The shanks performed well in stony fields; no problems occurred during the test. Maximum lift height to clear obstructions was 255 mm (10 in).

Penetration: When equipped with 50°, 406 mm (16 in) sweeps, penetration was very good in nearly all field conditions and it was easy to obtain sufficient seeding depth. Sufficient seeding depth could not be obtained only in extremely hard conditions such as dry, baked slough bottoms. Penetration was uniform across the cultivator width provided all depth control linkages and hitch height were kept properly adjusted.

The cultivator wheels were positioned so that each centre section wheel supported about 16% of the total cultivator weight while each wing wheel supported about 8%. In addition, each centre wheel supported about 14% of the total tillage suction force while each wing, wheel supported about 11%. Cultivator or pneumatic seeder sinking was not a problem in moderately soft soils. Since the pneumatic seeder was not supported by the cultivator wheels, but was carried on its own wheels, it did not contribute to cultivator sinking in soft soils.

Trash Clearance: The Friggstad B3-31 cultivator had excellent trash clearance. In heavy, loose trash it was necessary to either raise the mounted tine harrows or to release the tine angle adjustment to allow the trash to clear the harrows.

With the harrows correctly adjusted it was possible to operate in fields with a heavier trash cover than was possible with a conventional hoe drill.

Skewing and Stability: The Friggstad B3-31 cultivator, equipped with the PA1-40 applicator, was very stable and sideways skewing occurred only in very hilly conditions. The cultivator shank pattern was symmetrical and did not impose any side forces on the cultivator during normal tillage. When equipped with 406 mm (16 in) sweeps the cultivator had to skew more than 3° to miss weeds. Throughout the evaluation period skewing was never serious enough to cause weeds to be missed. Reasonable care had to be observed on steep hillsides, due to the high centre of gravity of the pneumatic seeder, especially with full grain and fertilizer tanks.

Weed Kill: Weed kill was very good when equipped with 406 mm (16 in) sweeps. The 305 mm (12 in) shank spacing resulted in 100 mm (4 in) sweep overlap. Considerable sweep wear could occur before weeds were missed. When sweeps wore to about 330 mm (13 in), larger weeds could work their way between the sweeps and be missed.

Fertilizer Banding: The Friggstad PA1-40 could be used for two types of fertilizer application. It could be used for normal fertilizer application at seeding time by metering fertilizer from one tank and grain from the other and applying both through the same seed boots. When equipped with chisel points and alternate banding boots (FIGURE 14), it could also be used for fertilizer banding.

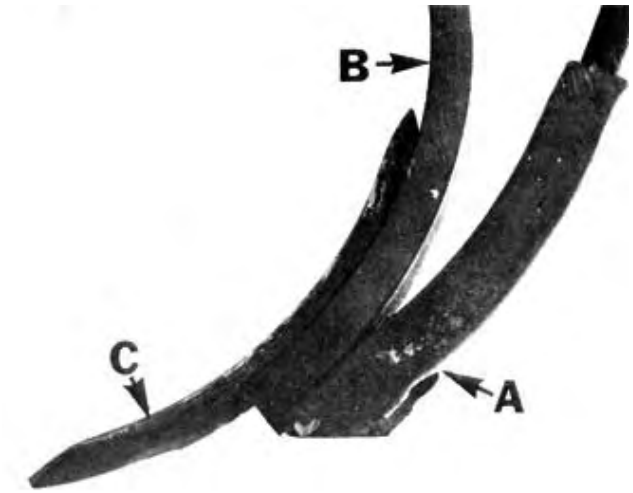

FIGURE 14. Friggstad Fertilizer Banding Boot: (A) Banding Boot (B) Cultivator Shank, (C) Chisel Point

Banding is a relatively new method of fertilizer application on the Prairies. Experimental results suggest that placing fertilizer in compact bands, from 35 mm (1.5 in) below seed depth to twice seeding depth is desirable for fall fertilizer application. This necessitates the use of chisel points to obtain suf cient depth and minimize soil disturbance and special boots to minimize fertilizer spreading. The Friggstad PA1-40 worked well for fertilizer banding.

Fertilizer granules were placed in a band about 30 mm (1.2 in) wide. Vertical fertilizer distribution generally ranged from chisel tip depth to 10 mm (0.4 in) above chisel tip depth.

The fan provided adequate air, for the 10.7 m (35 ft) cultivator, to allow both meters to be fully opened while distributing 11-51-0 fertilizer. When using a single tank and single metering system, fertilizer application rates up to 215 kg/ha (190 lb/ac) were possible with the Friggstad PA1-40. When using both tanks and both metering systems, application rates up to 430 kg/ha (380 lb/ac) were possible. However, at rates in excess of 200 kg/ha (180 lb/ac), fertilizer was blown over the meter side panels onto the ground. When the meters were fully opened, some fertilizer also leaked out around the meter barrels. As high application rates are commonly required for fertilizer banding, it is recommended that the manufacturer consider modi cations to reduce fertilizer losses at the meter system at high application rates.

When exposed to driving rain, some moisture entered the metering compartment. FIGURE 15 shows fertilizer caked to the metering utes after a rainfall. The metering system should be checked after rainfall for any caking of fertilizer as this will cause errors in application rates. The meters were made of a plastic material for corrosion resistance. All unprotected metal surfaces such as the meter adjustment threads should be cleaned and oiled periodically when applying fertilizer to prevent corrosion.

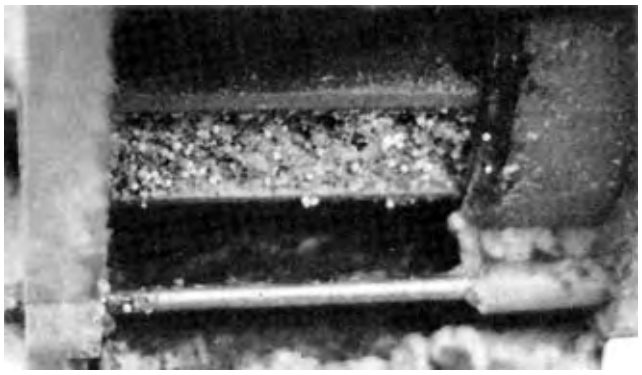

FIGURE 15. Caking of Fertilizer on the Meter Flutes as a Result of Rain Entering the Metering Compartment.

EASE OF OPERATION

Dual Purpose Operation: The Friggstad PA1-40 could be detached from the cultivator by two men in less than three hours. The disassembly included the removal of the cultivator hitch assembly, removal of the secondary headers from the header stands on the cultivator, removal of the stabilizer bar and meter drive at the rear of the applicator, pulling the applicator out of the cultivator hitch and reassembling the hitch on the cultivator. This allowed the cultivator to be used as a dual purpose machine, both for seeding and seasonal tillage.

Hitching: The Friggstad PA1-40 applicator and cultivator combination were easily hitched to a tractor. Hitching convenience was reduced by the fact that the hitch link did not remain horizontal when unhitched from the tractor. Hitching also required hook-up of four hydraulic lines with quick couplers and electrical connectors for the meter shut-off solenoid and the monitor system.

Filling: A drill ll or grain auger was needed to ll the applicator tanks. Because the ller openings were located 2.3 m (7.5 ft) above the ground, hand lling was dif cult as it necessitated carrying the grain or fertilizer up the access ladder. The large 430 x 1067 mm (17 x 42 in) ller openings gave ample room for auger lling. The ller lids were hinged and were latched by a simple crossbar with a wing nut tightener. The lids were equipped with weather stripping to prevent moisture entry.

The left tank held 2250 L (64 bu) while the right tank held 2740 L (78 bu).

Visibility: Visibility of the cultivator mainframe section was obstructed by the applicator. Care had to be observed when operating with the applicator to detect possible problems such as mainframe plugging.

Monitoring and Control System: The test machine was equipped with an electronic seed monitor and an optional electric shut-off which permitted monitoring of seed ow and starting or stopping the seed meters from the tractor seat.

The monitoring system was easy to install and use and performed well throughout the evaluation. It monitored material ow at the main meters and at each of the ve primary header outlet ports. Small holes were drilled in the meter side panels and primary header tubes to insert pin type sensors into the material ow paths at the various sensor locations. The monitoring system was activated by turning on the tractor mounted control box power switch. Material ow stoppage, at the seven locations monitored, was indicated by a warning beep and ashing monitor lights to indicate the blockage location. Although it was convenient to monitor ow at these seven locations, interruption of material ow at the 35 secondary outlets could still go unnoticed.

The optional electric meter shut-off could be installed to enable the operator to shut off either one meter or to shut off both meters while the meter drive wheel was still turning. Because the meter drive wheel stopped turning whenever the cultivator was raised out of the ground, the electric shut off was seldom used under normal seeding operations.

Seed and Fertilizer Boots: The seed and fertilizer boots performed well. Only one seed boot plugged with soil during the test period. This occurred while seeding in a wet area. No seed or fertilizer boot damage occurred in stony elds.

Cleaning: Access to the meter utes for cleaning was possible with full tanks, by closing the tank shut-off slides above each meter. A small door could then be opened beneath each meter. This door could also be used for emptying the tanks when the meter shut-off slides were open.

A vacuum cleaner or compressed air was needed for thorough cleaning of the right tank due to positioning of the main distribution tube. The left tank emptied completely through the meter inspection door. Access to the tanks was possible by removal of the tank screens, which covered the tank openings. The screens could be removed without tools.

Area Meter: No area meter was supplied with the Friggstad PA140. It is recommended that the manufacturer consider supplying a land area meter as standard equipment.

Transporting: A distinct advantage of cultivator mounted pneumatic seeders over conventional drills, is the ease with which relatively wide machines can be transported. The Friggstad applicator-cultivator-packer assembly was easily placed in transport position (FIGURE 16) in about ve minutes. Two hydraulic cylinders raised the cultivator wings to the upright position. Two additional hydraulic cylinders, connected in parallel with the cultivator transport cylinders, folded the packer drawbar wing sections rearward, as the cultivator wings raised. The cultivator had to be moving slowly forward while being placed in transport position to enable the packers to swing into transport position.

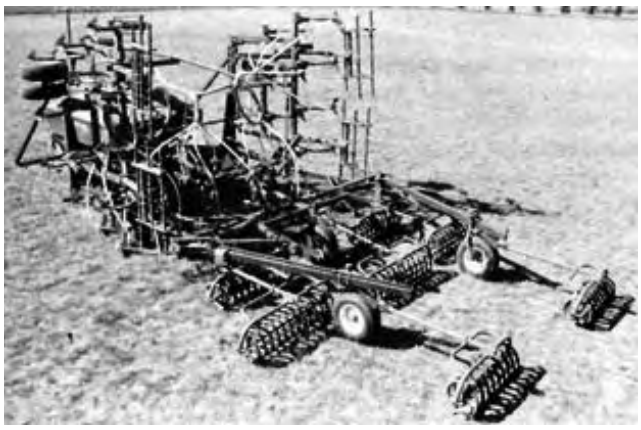

FIGURE 16. Transport Position.

The assembly towed well in transport position. For long distance travel, or for travel on paved roads, the packers could not be towed behind the cultivator and had to be transported separately. The packers were heavy and inconvenient to load on a truck or trailer. Overall transport width was 5840 mm (19.2 ft), requiring care when travelling on public roads.

EASE OF ADJUSTMENT

Lubrication: Lubrication was convenient with good access to all grease ttings. Four ttings on the applicator, three on the cultivator, three on the packer drawbar and two on each packer section required daily servicing. Five wheels on the applicator, eight on the cultivator and three on the packer drawbar required servicing every 100 hours.

Engine Servicing: The engine was positioned for convenient access. The recommended oil change interval for the engine was 100 hours. The location of the engine oil drain plug (FIGURE 17) caused oil from the engine to run onto the engine electrical components during oil changes. It is recommended that the manufacturer provide a tray beneath the engine to prevent this.

Engine fuel consumption was about 3.8 L/h (0.85 gal/h). The engine could run about 30 hours on one lling of the 125 L (27.5 gal) tank.

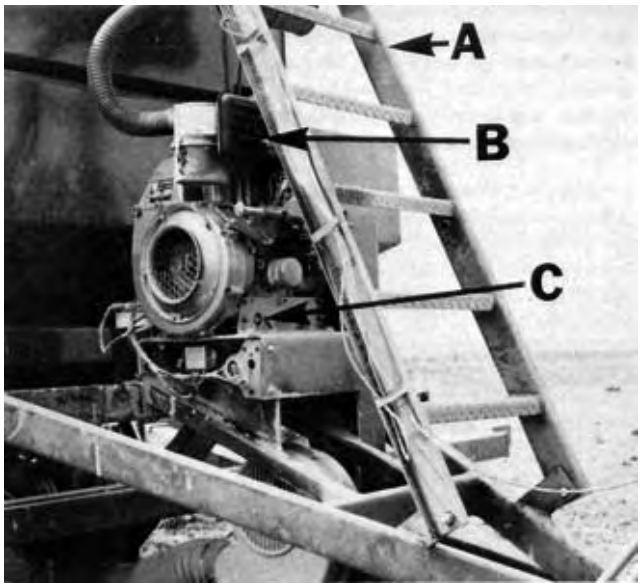

FIGURE 17. Engine: (A) Access Ladder, (B) Muf er, (C) Oil Drain Plug.

Application Rate: Application rate was easily changed by a threaded adjusting screw on each meter (FIGURE 18). The meter scale was adjustable from 0 to 110 in increments of one. Calibration charts included in the operator's manual showed application rates for each scale setting, in pounds per acre. Fingers which covered the inner area of the uted wheel could be used for small seeds such as rapeseed. These ne settings could be obtained without tools by swivelling a meter stop to hold the ngers. The ne adjustment then became exposed when the meter control was operated. These ne settings used the same meter scale but could be adjusted only from 0 to 25.

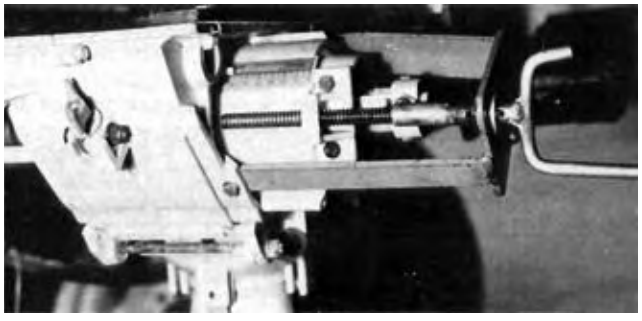

FIGURE 18. Application Rate Adjustment.

It was possible to adjust for relatively precise seeding rates, due to the small scale divisions. For example, in Neepawa wheat, each scale division changed the seeding rate by only 1.8 kg/ha (1.6 lb/ac).

Depth Adjustment: Seeding depth was conveniently adjusted with a single hydraulic cylinder. Each tandem wheel set of the cultivator was linked to the depth control cylinder with chains and connector links. An adjustable, eccentric depth stop could be used to set maximum depth. Two wrenches were needed to position the depth stop.

The frame was levelled by positioning the hitch link in one of six positions and by adjusting a threaded connector bolt on each tandem wheel depth control linkage. Repositioning the hitch link required the use of wrenches.

RATE OF WORK

The Friggstad PA1-40 was operated at speeds of 5 to 10 km/h (3 to 6 mph). Overall best performance, in terms of weed kill and seed placement, was obtained at speeds of 8 to 10 km/h (5 to 6 mph) resulting in eld work rates, for the 10.7 m (35 ft) unit, ranging from 8.6 to 10.7 ha/hr (21 to 27 ac/hr). Using both tanks, when seeding wheat at a rate of 85 kg/ha (75 lb/ac), about 45 ha (110 ac) could be seeded before re lling. Using only the larger tank, about 25 ha (60 ac) could be seeded before re lling. This compares to 15 to 25 ha (40 to 60 ac) between re lls for most conventional drills of similar width.

POWER REQUIREMENTS

Draft Characteristics: Attempting to compare draft requirements of different makes of heavy duty cultivators usually is unrealistic. Draft requirements for the same cultivator, in the same eld, may vary by as much as 30% in two different years, due to changes in soil conditions. Variation in soil conditions affect draft much more than variation in machine make, usually making it impossible to measure any signi cant draft difference between makes of heavy duty cultivators. The power requirements given in TABLES 2 and 3 are based on average draft requirements of 10 makes of heavy duty cultivators in 40 different eld conditions[3]. Additional draft due to the applicator with full tanks, the mounted harrows and the packers has been included.

TABLE 2. Tractor Size (Maximum Power Take-off Rating, kW) to Operate the Friggstad PA140 Applicator with 10.7 m B3-31 Cultivator, H3-40 Packer Drawbar and Inland Packers in Light Primary Tillage.

DEPTH (mm)	SPEED (km/h)					
	7	8	9	10	11	12
50	76	91	106	123	141	159
75	100	119	137	157	178	201
100	124	146	166	193	217	243
125	145	174	199	225	257	284

TABLE 3. Tractor Size (Maximum Power Take-off Rating, kW) to Operate the Friggstad PA140 Applicator with 10.7 m B3-31 Cultivator, H3-40 Packer Drawbar and Inland Packers in Heavy Primary Tillage.

DEPTH (mm)	SPEED (km/h)					
	7	8	9	10	11	12
50	70	83	97	112	129	145
75	118	139	160	182	205	229
100	167	195	223	251	282	312
125	216	250	286	322	356	396

Tractor Size: TABLES 2 and 3 show tractor sizes, needed to operate the Friggstad PA1-40 applicator, with the 10.7 m (35 ft) B3-31 heavy duty cultivator, the H3-40 packer drawbar and Inland packers, in light and heavy primary tillage. Tractor sizes have been adjusted to include tractive ef ciency and represent a tractor operating at 80% of maximum power on a level eld. The sizes presented in the tables are the maximum power take-off rating, as determined by Nebraska tests or as presented by the tractor manufacturer. Selected tractor sizes will have ample power reserve to operate in the stated conditions.

Tractor size may be determined by selecting the desired tillage depth and speed from the appropriate table. For example, in light primary tillage at 75 mm (3 in) depth and 8 km/h (5 mph), a 119 kW (180 hp) tractor is required to operate the seeding unit. In heavy tillage at the same depth and speed a 139 kW (185 hp) tractor is needed.

OPERATOR SAFETY

Although the ladder (FIGURE 17) provided convenient access to the tank openings, caution had to be used. Most operators had a tendency to descent the ladder facing the tractor hitch, rather than facing the tanks. The absence of a handrail made descending the steps this way quite hazardous. The engine exhaust muf er was also located close to one of the steps, making it possible for the operator's hands to touch the muf er when climbing the ladder. Access to the base of the ladder was from the applicator frame rails, which did not provide a safe convenient foothold for ladder access. It is recommended that the manufacturer provide a platform at the base of the ladder for convenient and safe ladder access as well as a handrail for increased operator safety when climbing or descending the ladder.

Extreme caution is needed in transporting most folding cultivators to avoid contacting power lines. Minimum power line heights vary in the three prairie provinces. In Saskatchewan, the energized line may be as low as 5.2 m (17 ft) over farm land or over secondary roads, in Alberta and Manitoba, the neutral ground wire may be as low as 4.8 m (15.7 ft) over farm land. In all three provinces, feeder lines in farmyards may be as low as 4.6 m (15 ft).

The Friggstad PA1-40 applicator with Friggstad B3-31 10.7 m (35 ft) cultivator was 4.3 m (14 ft) high in transport position, permitting safe transport under prairie power lines. On the other hand, transport height with the 12.5 m (41 ft) wide model of the same cultivator is 5.2 m (17.1 ft), which is high enough for contact with many prairie power lines. The legal responsibility for safe passage under utility lines rests with the machinery operator and not with the power utility or the machinery manufacturer. All provinces have regulations governing maximum permissible equipment heights on various public roads. If height limits are exceeded, the operator must contact power and telephone utilities before moving.

The Friggstad PA1-40 with B3-31 cultivator was 5.8 m (19.2 ft) wide in transport position. This necessitated caution when towing on public roads, over bridges and through gates.

No slow moving vehicle sign was provided. It is recommended that a slow moving vehicle sign be provided as standard equipment. Pins were provided to lock both the depth control cylinder and the wings in transport position.

The Friggstad PA1-40 applicator with the B3-31 cultivator, without packers, towed well at speeds up to 28 km/h (17 mph). Centre section tire loads on the B3-31 cultivator, in transport position, exceeded the Tire and Rim Association maximum load rating for 9.5L x 15, 8-ply tires by 24%. This tire load could be unsafe at high transport speeds and appropriate caution should be used when transporting on public roads.

Total engine and fan noise level at the tractor hitch point was about 100 dbA. This increased the operator station noise level in most modern tractor cabs by only 2 dbA. For example, in one tractor cab, operator station noise level was 79 dbA with the tractor operating and 81 dbA with the tractor and pneumatic applicator operating. Suitable ear protectors should be worn if the tractor is not equipped with an appropriate cab.

OPERATOR'S MANUAL

The operator's manual for the Friggstad PA1-40 applicator contained useful information on safety, adjustments, maintenance and operation. Calibration charts and a detailed parts list were also included. A metric calibration chart was not included. It is recommended that the manufacturer consider supplying a metric calibration to aid in metric conversion.

DURABILITY RESULTS

TABLE 4 outlines the mechanical history of the Friggstad PA1-40 applicator, the B3-31 heavy duty cultivator, H3-40 packer drawbar and the Inland packers during 132 hours of eld operation while seeding about 800 ha (1980 ac). The intent of the test was evaluation of functional performance. An extended durability evaluation was not conducted.

DISCUSSION OF MECHANICAL PROBLEMS

APPLICATOR

Engine: Although no engine problems were experienced, the manufacturer replaced the engine after the completion of the eld evaluation. This replacement was the result of a manufacturer changeover intended to increase engine service life while operating in severe dust conditions.

Castor Wheels: Both applicator castor wheels tended to stick on corners during the rst 30 hours of the test. A manufacturer's service bulletin, updating the machine, provided for the installation of grease ttings in the upper portion of the castor swivel pipes in addition to ttings, already located on the lower portion. No further problems occurred after the two upper grease ttings were installed.

TABLE 4. Mechanical History.

ITEM	OPERATING HOURS	EQUIVALENT FIELD AREA (ha)
APPLICATOR		
-The castor wheels trailed incorrectly at	beginning of test	
-A seed monitor wire broke at the monitor connection and was repaired at	50	310
-The meter ground wheel drive hydraulic motor loosened on its shaft and fell off at	120	750
-The fan drive belts were replaced at	120	750
-The fan drive engine was replaced by the manufacturer at	132	800
CULTIVATOR		
-The sweeps running behind the tractor and cultivator wheels were replaced at	60	371
-All sweeps were replaced at	120	750
PACKER DRAWBAR		
-The right packer drawbar pin fell out, causing the left clevis tongue to twist off, pulling the end off one drawbar hydraulic quick connector at	56	350
-The castor wheels twisted on the frame	throughout the test	
-A stop was welded on the drawbar packer hitch at	120	750
PACKERS		
-A packer axle bearing holder broke, causing the other bearing holder to break at	92	570
-The packer axle bearing grease fittings were damaged by rocks	throughout the test	

PACKER DRAWBAR

Castor Wheels: The U-bolts fastening the castor wheels to the packer frame, allowed the castor wheels to twist on the wing frame. This caused interference between the packer hitch and the frame when the castor wheel turned (FIGURE 19). Another problem was that the packer hitch pivot was not equipped with a stop and could interfere with the tire. A stop was welded on the packer hitch to avoid the interference. It is recommended that modi cations be made to the castor wheel assemblies to eliminate twisting and tire interference.

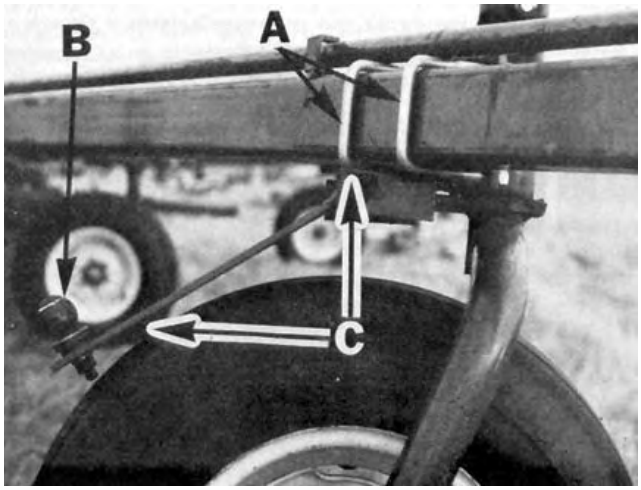

FIGURE 19. Packer Castor Wheel Twisting: (A) U-bolts, (B) Packer Hitch, (C) Interference.

[3]See PAMI Evaluation Report E2178A.

APPENDIX I

SPECIFICATIONS
(A) PNEUMATIC APPLICATOR

MAKE:	Friggstad Pneumatic Applicator
MODEL:	PA1-40
SERIAL NO.:	P80 175
MANUFACTURER:	Friggstad Manufacturing Ltd. P.O, Box 150 Frontier, Saskatchewan S0N 0W0
DIMENSIONS:	
- width	2690 mm
- length	4035 mm
- height	4085 mm
- maximum ground clearance	225 mm
- wheel tread	2388 mm
METERING SYSTEM:	
- type	externally fluted feed wheel
- number of meters	2
- drive	hydraulic motor from ground drive wheel
- adjustment	
- coarse	threaded adjustment for area of flute exposure
- fine	threaded adjustment for area of alternate shallow flute exposure
- transfer to openers	pneumatic conveyance through divider headers and plastic tubes
TANK AGITATOR:	
- type	steel prongs on rotating rod
- drive	hydraulic motor from ground drive wheel
TANK CAPACITIES:	
- left	2250 L (54 bu)
- right	2740 L (78 bu)
Total	4990 L (142 bu)
FAN:	
- type	forward curved centrifugal
- operating speed	5000 rpm
- drive triple	V-belt
ENGINE:	
- make	Wisconsin Air Cooled 4-Stroke Diesel
- model	WD2-1000
- serial no.	095 454005
- power rating	12.7 kW @ 2200 rpm
- starting system	12 volt electric
- fuel tank capacity	125 litres
WHEELS:	
- dual castor wheels	4 - 11L x 15, 12-ply implement
- meter drive wheel	6.70 x 15, 4-ply traction rug
NUMBER OF LUBRICATION POINTS:	4 grease fittings, 10 hr service 5 wheel bearings, 100 hr service

OPTIONAL EQUIPMENT:
- PAI-40 available for working widths of 10.7 m or 12.2 m
- electric solenoid meter shut-off
- H3-40 packer drawbar

(B} CULTIVATOR

MAKE:	Friggstad Heavy Duty Cultivator
MODEL:	B3-31
SERIAL NO.:	B80-147
MANUFACTURER:	Friggstad Manufacturing Ltd. P.O, Box 150 Frontier, Saskatchewan S0N 0W0
SHANKS:	
- number	35
- lateral spacing	305 mm
- trash clearance(sweep to frame)	730 mm
- number of shank rows	3
- distance between rows	varies from 650 mm to 1260 mm across cultivator width
- shank cross section	32 x 50 mm
- shank stem angle	52°
- sweep hole spacing	57 mm
- sweep bolt size	11 mm
HITCH:	
- vertical adjustment range	355 mm in 6 positions
DEPTH CONTROL:	hydraulic
FRAME:	
- cross section	100 mm square tubing, 6 4 mm thickness
TIRES:	8 - 9.5 L x 15, 5-ply implement
NUMBER OF LUBRICATION POINTS:	3 grease fittings, 10 hr service 8 wheel bearings, 100 hr service
HYDRAULIC CYLINDERS:	
- depth control	1 - 27 x 406 mm
- wing lift	2 - 100 x 762 mm

OPTIONAL EQUIPMENT:
- 6 width options in the three section model varying from 107 m to 12,5 m
- frame mounted 3-row spring tine harrows

(C) PACKER DRAWBAR

MAKE:	Friggstad Packer Drawbar
MODEL:	H3-40
SERIAL NO.:	H-80-34
MANUFACTURER:	Friggstad Manufacturing Ltd. PO Box 150 Frontier, Saskatchewan S0N 0W0
DRAWBAR ATTACHMENT:	two pin hinge clevises to rear mainframe of cultivator
FRAME:	100 mm square tubing, 8.4 mm thickness
WHEEL SUPPORT:	1, mainframe section spring damped castor 2, wing section, trailing castor, width adjustable
TIRES:	3 - 9.5L x 15, 6-ply, implement
NUMBER OF LUBRICATION POINTS:	3 grease fittings, 10 hr service 3 wheel bearings, 100 hr service
PACKER ATTACHMENT:	trailer type ball and socket quick connector
HYDRAULIC CYLINDERS:	2, 100 x 610 mm

OPTIONAL EQUIPMENT:
- three width options for working widths of 107 to 171 m

(D) PACKERS

MAKE:	Inland Trailing Steel Coil Packers
MANUFACTURER:	Inland Steel & Forgings Ltd. 675 Washington Avenue Winnipeg, Manitoba R2K 1M4

	WIDTHS	**WEIGHTS**
	2 - 1260 mm	2 - 170 kg
	2 - 1540 mm	2 - 200 kg
	3 - 1820 mm	3 - 250 ka
Total	11,060 mm	1490 kg

COIL DIAMETER:	460 mm
COIL PITCH:	142 mm
LUBRICATION:	2 grease fittings per packer section

(E) OVERALL SPECIFICATIONS FOR APPLICATOR-CULTIVATOR-PACKER ASSEMBLY

DIMENSIONS:	**FIELD POSITION**	**TRANSPORT POSITION**
- overall width	11,320 mm	5840 mm
- overall length	12,400 mm	13,340 mm
- overall height	4060 mm	4340 mm
- ground clearance	230 mm	230 mm
- wheel tread	9040 mm	3500 mm

WEIGHTS:	**TANKS EMPTY**	**TANKS FULL OF WHEAT**
- hitch	645 kg	1570 kg
- left applicator castor	585 kg	2020 kg
- right applicator castor	670 kg	2130 kg

	FIELD POSITION	**TRANSPORT POSITION**
- left centre cultivator wheels	2770 kg	2610 kg
- right centre cultivator wheels	1770 kg	2610 kg
- left wing cultivator wheels	845 kg	
- right wing cultivator wheels	835 kg	
- center packer drawbar wheel	470 kg	470 kg
- left packer drawbar wheel	125 kg	125 kg
- right packer drawbar wheel	125 kg	125 kg
Total, Tanks Empty	7840 kg	
Total, Tanks Full of Wheat		11,660 kg

APPENDIX II

MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

(a)excellent	(d) fair
(b) very good	(e) poor
(c) good	(f) unsatisfactory

APPENDIX III

CONVERSION TABLE

1 hectare (ha)	= 2.5 acres (ac)
1 kilometre/hour (km/h)	= 0.6 miles/hour (mph)
1 metre (m)	= 3.3 feet (ft)
1 millimetre (mm)	= 0.04 inches (in)
1 kilowatt (kW)	= 1.3 horsepower (hp)
1 kilogram (kg)	= 2.2 pounds (lb)
1 newton (N)	= 0.2 pounds force (lb)
1 litre (L)	= 0.03 bushels (bu)
1 kilogram/hectare (kg/ha)	= 0.9 pounds/acre (lb/ac)
1 kilogram/cubic metre (kg/m^3)	= 0.08 pounds/bushel (lb/bu)
1 kilonewton/metre (kN/m)	= 70 pounds force/foot (lb/ft)

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