Evaluation Report

Flexi-coil Air FlowSeeder

SUMMARY AND CONCLUSIONS
Overall functional performance of the Flexi-coil air flow seeder was good in all seeding conditions. Performance was good when banding fertilizer. When operated with the 10.7 m (35 ft) John Deere 1610 heavy duty cultivator, the Flexi-coil was suitable for seeding both in primary and secondary tillage conditions. The Flexi-coil was also suitable for banding fertilizer at application rates up to 365 kg/ha (325 lb/ac) at 9 km/h (5.5 mph). Higher application rates were possible at reduced speeds.

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 eulds under the same seeding conditions. Row spacing and seed band width behind each seed boot provided ample stubble for good window support. Maintaining good cultivator frame levelling and ensuring a seed depth of at least 50 mm (2 in) were critical in ensuring good emergence.

The manufacturer’s metering system calibrations were acceptable in wheat, barley, oats, and fertilizer. The manufacturer’s meter calibration was inaccurate for rapeseed.

Distribution uniformity was acceptable in wheat and barley at normal seeding rates and at rates up to 50 kg/ha (45 lb/ac) in oats. Distribution in rapeseed and fertilizer was unacceptable at all application rates.

Field bounce, euld slope and ground speed had little effect on metering rates. Distribution uniformity was only slightly affected by euld slope.

Seeding rate was easily adjusted. Tank and meter cleanout convenience was fair. Tank lling required the use of a drills or auger. Eleven grease ttings and two wheel bearings on the applicator required greasing.

Operator visibility of the cultivator was obstructed by the tanks.

The Flexi-coil with John Deere 1610 heavy duty cultivator could be placed in transport position in less than 10 minutes. Rate of work usually ranged from 8.6 to 10.7 ha/hr (21 to 27 ac/hr). About 58 ha (142 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, ground speed, cultivator width, and soil nishing attachments. In light primary tillage, at 75 mm (3 in) depth and 8 km/h (5 mph), a 107 kW (144 hp) tractor was needed to operate the applicator-cultivator combination. In heavy primary tillage at the same depth and speed, a 128 kW (173 hp) tractor was needed.

The cultivator centre frame tires were slightly overloaded in transport position and the applicator tires were overloaded with full tanks.

RETAIL PRICE: (February, 1982, f.o.b. Lethbridge, Alberta).

a. Flexi-coil air ow seeder complete with seed boots and distribution system to feed 35 shanks. $23,375.00
b. John Deere 1610 10.7 m (35 ft) heavy duty cultivator complete with attached harrows. $21,341.00

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

Only minor mechanical problems occurred during the evaluation.

RECOMMENDATIONS
It is recommended that the manufacturer consider:
1. Improving the front meter calibration for metering rapeseed.
2. Supplying meter calibrations for all grains in SI units.
3. Modifying cations to the distribution system to improve distribution uniformity in oats, fertilizer and rapeseed.
4. Moving the applicator wheels rearward to reduce applicator hitch bouncing.
5. Modifying the tank lid to reduce the force required to open and close the lid.
6. Providing, as optional equipment, a monitoring system to monitor material ow.
7. Providing an area meter as standard equipment.
8. Providing protection around the fan engine exhaust and shut-o for improved operator safety.

Senior Engineer: E. H. Wiens
Project Engineer: R. K. Allam

THE MANUFACTURER STATES THAT
With regard to recommendation number:
1. Improving the front meter calibration for rapeseed is under study.
2. Meter calibrations in SI units will be supplied with air seeders manufactured in 1982.
3. Testing of cations to improve the distribution uniformity is presently under way.
4. The axle, on units manufactured in 1982, will be moved rearward. Our tests have shown this eliminates the bounce problem, provides weight transfer to the tractor hitch and maintains good turning ability of the air seeder/cultivator unit.
5. Units manufactured in 1982 will have a crank operated lid.
6. A monitoring system, to be standard on units manufactured in 1982, will monitor material ow, fan speed, feed shaft rotation, bin levels, engine oil, charging rate and area covered. It will also be available, at extra cost, for existing air seeders.
7. See item 6.
8. Air seeders, manufactured in 1982, will have a remote engine control panel with engine tachometer/hour meter, cable actuated throttle and shut-o, start switch, light switch, and engine indicator lights.
NOTE: This report has been prepared using SI units of measurement. A conversion table is given in APPENDIX III.

GENERAL DESCRIPTION

The Flexi-coil air flow seeder is a pneumatic seed and fertilizer applicator designed for use with varying makes and models of light, medium and heavy duty cultivators.

The cultivator is attached to the rear of the applicator with the standard cultivator hitch. The applicator is supported by two wheels, each on single axles.

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. The applicator can be used for seeding, for combined seed and fertilizer application, and for fertilizer banding.

Seed or fertilizer are metered from the front tank through an adjustable uted roll mounted below the tank. Material is metered from the rear tank by varying the gate opening above a conveyor belt. The meters are driven by a series of chains and sprockets from the right applicator wheel. Metered material passes through an air lock before entering the air stream. 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 feeding ve, seven-port secondary headers, all of which are mounted on the cultivator frame. Tubes from the secondary headers connect to the seed boots.

The test machine was used with a John Deere 1610 heavy duty cultivator. This cultivator was 10.7 m (35 ft) wide with a 4.0 m (13.1 ft) centre frame and two 3.3 m (10.6 ft) wing sections.

It was equipped with 35 spring cushioned shanks, spaced at 305 mm (12 in), arranged in three rows. The cultivator was equipped with optional three-row mounted harrows. A tractor with three remote hydraulic controls was required to operate the Flexi-coil air flow seeder with the John Deere 1610 cultivator.

Detailed specifications for the pneumatic applicator and cultivator are given in APPENDIX I while FIGURE 1 shows the location of major components.

SCOPE OF TEST

The Flexi-coil was operated in loam and clay soils in the field conditions shown in TABLE 1 for approximately 108 hours while processing about 770 ha (1900 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

<table>
<thead>
<tr>
<th>CROP</th>
<th>FIELD TILLAGE CONDITIONS</th>
<th>STONE CONDITIONS</th>
<th>FIELD AREA (ha)</th>
<th>HOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durum wheat on summerfallow</td>
<td>Secondary</td>
<td>Occasional stones</td>
<td>65</td>
<td>9</td>
</tr>
<tr>
<td>Spring wheat on stubble</td>
<td>Secondary</td>
<td>Occasional stones</td>
<td>75</td>
<td>10</td>
</tr>
<tr>
<td>Spring wheat on stubble</td>
<td>Primary</td>
<td>Occasional stones</td>
<td>115</td>
<td>15</td>
</tr>
<tr>
<td>Winter wheat on stubble</td>
<td>Primary</td>
<td>Stone free</td>
<td>316</td>
<td>52</td>
</tr>
<tr>
<td>Banding fertilizer</td>
<td>Primary</td>
<td>Occasional stones</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>770</td>
<td>106</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

QUALITY OF WORK

Metering Accuracy: The grain and fertilizer metering system was calibrated in the laboratory1 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 significantly affect grain crop yields.

Calibration curves for wheat, barley, oats and 11-51-00 fertilizer are given in FIGURES 2 to 5 for the front and rear metering systems. PAMI's calibration curves are compared to the manufacturer's calibration curves. At a seeding rate of 80 kg/ha (70 lb/ac), measured rates agreed with the manufacturer's calibration in wheat for both tanks, were 10 and 14% higher than the manufacturer's rate for barley with the front and rear meters, respectively, were 7% higher than the manufacturer's rates and accurate for oats with front and rear meters, respectively, and accurate with 11-51-00 fertilizer for both meters.

FIGURE 2. Metering Accuracy in Wheat.

FIGURE 3. Metering Accuracy in Barley.

FIGURE 4. Metering Accuracy in Oats.

The rear metering system was not suitable for seeding rapeseed. FIGURE 6 shows the calibration curves while metering rapeseed with the front meter. At a seeding rate of 7 kg/ha (6.2 lb/ac) in rapeseed, the measured seeding rate was 26% higher than the manufacturer's rate. At a seeding rate of 4 kg/ha (3.6 lb/ac), the

1T773, “Detailed Test Procedures for Grain Drills”
measured seeding rate was 65% lower than the manufacturer’s rate. It is recommended that the manufacturer’s calibration accuracy for rapeseed be improved.

Operating on side slopes and hills had only a minor effect on metering rates. For example, when operating on a 10 degree side slope, metering rates with both wheat and fertilizer could decrease as much as 8%. When going down a hill, the metering rate on the rear meter could increase by as much as 10% for both wheat and fertilizer. An increase in ground speed from 4.8 to 12 km/hr (3 to 7.5 mph) decreased the front metering rate by 7% in wheat and 11% in 11-51-00 fertilizer. Variations in ground speed did not affect the rear meter. Although ground drive wheel slippage in soft fields is common with many ground driven applicators, no ground drive wheel slippage of the large diameter drive wheel was experienced with the Flexi-coil.

Distribution Uniformity: FIGURE 7 gives seeding distribution uniformity for the Flexi-coil in wheat, barley and oats at a fan speed of 3000 rpm. Changes in fan speed had very little effect on distribution patterns. For example, in wheat, varying the fan speed from 2500 to 3500 rpm, resulted in coefficients of variation (CV) of 12.2 and 11%, respectively. Distribution was uniform over the normal range of seeding rates for wheat and barley. For example at a seeding rate of 80 kg/ha (70 lb/ac) the CV was 9.8% for both wheat and barley. Distribution uniformity was unacceptable in oats for seeding rates above 50 kg/ha (45 lb/ac).

It is recommended that modifications be made to the Flexi-coil distribution system to improve distribution uniformity in oats, fertilizer and rapeseed.

Changes in distribution pattern uniformity could occur at different forward speeds or for different machine widths due to different volumes of material being introduced into the constant

FIGURE 8 gives seeding distribution uniformity in rapeseed at a fan speed of 2500 rpm. Although decreasing the fan speed from 2500 to 1500 rpm resulted in the CV decreasing from 30.8 to 23.5% respectively, distribution patterns were unacceptable over the full range of fan speeds. FIGURE 8 shows that at a fan speed of 2500 rpm, distribution uniformity is unacceptable over the entire seeding range with CV’s varying from 26.4 to 30.8%. FIGURE 9 shows unacceptable distribution uniformity for 11-51-00 fertilizer at all application rates.

4The coefficient 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. If the CV is greater than 15%, the variation in application rate among individual shanks is excessive.
Seeding or fertilizing up or down a 10 degree slope had little effect on distribution uniformity.

Grain Damage: Grain damage by the metering and distribution system was within acceptable limits for cereal grains at fan speeds below 3500 rpm. For example, in dry Neepawa wheat at 11.2% moisture content and a fan speed of 3000 rpm, only 0.3% cracking occurred. Wheat cracking at the same moisture content increased to 0.9% at a fan speed of 3500 rpm. In dry rapeseed with a moisture content of 7% cracking at a fan speed of 3000 rpm was 7.6%. Reducing fan speed to 2500 and 2000 rpm reduced rapeseed cracking to 1.6 and 0.6% respectively. Due to excessive rapeseed damage at higher fan speeds, it is suggested that a maximum fan speed of 2500 rpm be recommended for rapeseed.

Seed Placement: Each seed boot was equipped with a V-shaped deflector (Fig. 10) to spread the seed behind each cultivator sweep. After the spring seeding period, the manufacturer supplied alternate seed boots with stronger V-shaped deflectors to replace the original seed boots. Some deflectors on the original seed boots became deformed by hard soil and rocks. All seed placement measurements taken were in fields seeded with the original seed boots. Although rows were visible when grain first emerged, in most fields, after complete crop emergence, it was difficult to observe distinct plant rows. Therefore, even with 305 mm (12 in) cultivator shank spacing there was sufficient stubble for windrow support at harvest time (Fig. 11).

Although seeds were usually placed on the furrow bottom at the working depth of each individual cultivator sweep, depth across the width of the machine varied due to cultivator frame geometry and non-uniform field surfaces. On level and gently rolling fields, vertical seed distribution was quite uniform. For example, at an average seed depth of 65 mm (2.5 in), seeding depth across the width of the machine varied from 40 to 95 mm (1.6 to 3.7 in) with most of the seeds being placed within 17 mm (0.7 in) of the average cultivator working depth. This compares to a vertical variation of from 12 to 15 mm (0.45 to 0.6 in) from average seeding depth for a hoe drill in similar conditions.

In fields 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 tillage conditions. The shanks on the John Deere 1610 cultivator were sufficiently rigid to maintain a fairly uniform sweep pitch (Fig. 13) with resultant uniform tillage depth, over a wide range of soil conditions.

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.

Seeding Depth: It is very important to seed deep enough to obtain uniform seed coverage. Correct cultivator adjustment for pneumatic seeding was 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 fields to ensure adequate, uniform seed coverage.

Soil Finishing: For this evaluation, the John Deere 1610 cultivator was equipped with optional three-row mounted harrows. The mounted harrows were effective in smoothing the soil surface and in breaking soil lumps when adjusted to maximum ground pressure. The harrows also increased weed kill by loosening weeds.

The Flexi-coil with John Deere 1610 cultivator was not equipped with packers. Since it was considered essential to pack most fields in the field with packers, the John Deere 1610 Flexi-coil, a harrow-packer drawbar equipped with a harrow and packer combination was used as a follow-up operation. The harrow-packer combination served to further smooth and pack the seedbed, leaving packer ridges from 25 to 30 mm (1 to 1.2 in). To obtain a smooth, firm seedbed in dry conditions required packer drawbar operations in two directions. Care had to be used in moist conditions to avoid over-packing the seedbed. Figure 12 shows a typical seedbed after seeding into stubble both before and after use of the packer drawbar.

Shank Characteristics: The John Deere 1610 cultivator was equipped with adjustable spring cushioned shank holders. During the evaluation, it was used with 406 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 (Fig. 13) varied only 3 degrees over the full range of draft 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 10. Flexi-coil Seed Boot: (A) Seed Boot, (B) V-shaped Deflector, (C) Sweep.


*See Machinery Institute Evaluation Report 277
Cushioning spring preload, with new shanks, was exceeded at drafts greater than 7.3 kN/m (500 lb/ft), occurring just beyond the normal primary tillage draft range, indicating the John Deere 1610 was suited for heavy primary tillage.

The shanks performed well in stony fields. Maximum lift height to clear obstructions was 210 mm (8.3 in).

**FIGURE 12.** Flexi coil Seedbed (Upper: Before Packing, Lower: After Packing).

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

**Penetration:** When equipped with 50 degree, 406 mm (16 in) sweeps, penetration was good in most field conditions and it was easy to obtain correct seeding depth. Correct seeding depth could not be obtained in hard conditions such as dry, baked slough bottoms or in fields with abnormally hard furrow 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 wheel supported about 16% of the total cultivator weight while each wing wheel supported about 9%. In addition, each center wheel supported about 13% of the total suction force while each wing wheel supported about 12%. 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 John Deere 1610 cultivator had excellent trash clearance. The John Deere mounted harrows had to be raised to clear heavy loose trash.

With the harrows properly 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 John Deere 1610 cultivator and Flexi-coil applicator combination were 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 degrees to miss weeds. Throughout the evaluation period, in normal seeding conditions, 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 applicator, especially with full grain and fertilizer tanks.

Whenever the material level in the front tank was lower than the rear tank, the Flexi-coil hitch weight would become negative, causing the applicator hitch to bounce up and down on the tractor drawbar. This motion was undesirable as it alternately raised and lowered the cultivator hitch by as much as 50 mm (2 in). It is recommended that the manufacturer consider moving the applicator wheels rearward to reduce applicator hitch bouncing.

**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. However, to ensure adequate sweep lift is maintained for proper seed placement, sweeps should be replaced before significant wear is evident.

**Fertilizer Banding:** The Flexi-coil could be used for two types of fertilizer applications. 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. With chisel points, and alternate banding boots (FIGURE 14), it could also be used for fertilizer banding.

**FIGURE 14.** Flexi coil Banding Boot: (A) Cultivator Shank, (B) Banding Boot, (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 requires the use of chisel points to obtain sufficient depth and minimize soil disturbance and special boots to minimize fertilizer spreading.

The Flexi-coil worked well for fertilizer banding. Fertilizer granules were placed in a band about 25 mm (1 in) wide. Vertical fertilizer distribution generally ranged from chisel tip depth to 10 mm (0.4 in) above chisel tip depth. Wider fertilizer bands were obtained as the chisel points became worn.

The fan did not provide adequate air to allow both meters to be fully opened while distributing 11-51-00 fertilizer. When using both tanks, the air supply at a maximum fan speed of 3600 rpm,
was adequate to apply 440 kg/ha (392 lb/ac) with the 10.7 m (35 ft) cultivator at 9 km/h (5.5 mph). At higher application rates, plugging occurred in the hoses between the secondary header and seed boots. When using the rear or front tank only, fertilizer rates of 300 and 200 kg/ha (270 and 160 lb/ac), respectively, were possible.

Bandung suitability at 9 km/h (5.5 mph) was reduced for application rates greater than 385 kg/ha (325 lb/ac) due to the rapid deterioration of the distribution uniformity (FIGURE 9) at higher rates. Higher application rates with suitable distribution uniformity could be obtained by reducing forward speed. For example, the application rate could be increased to about 410 kg/ha (365 lb/ac) at 6 km/h (5 mph).

When exposed to driving rain, some moisture entered the metering compartment. The metering system should be checked after rainfall for any caking of fertilizer to avoid errors in application rates. The Flexi-coil tanks were coated inside with an epoxy paint for corrosion protection. All unprotected metal surfaces such as the meter adjustment lock bolts should be cleaned and oiled periodically when applying fertilizer, to prevent corrosion.

EASE OF OPERATION

Dual Purpose Operation: The Flexi-coil could be detached from the cultivator by two men in about one hour, A hoist or front end loader was required to remove the primary header stand from the cultivator. The secondary headers and hoses also had to be removed from the cultivator, allowing the cultivator to be used as a dual purpose machine, both for seeding and seasonal tillage.

Hitching: The Flexi-coil air ow seeder was easily hitched to a tractor. Hitching convenience was increased by the fact that the hitch link aed horizontal when unhitched from the tractor. Hitching also required hook-up of six hydraulic lines with quick couplers. Filling: A drill il or grain auger was needed to il the applicator tanks. Because the iler openings were located 2.4 m (6 ft) above the ground, hand iling was difficult as it necessitated carrying the grain or fertilizer up the access ladder. The large 1260 x 690 mm (50 x 35 in) iler openings gave ample room for auger iling. The iler lid was mounted on over-centre hinges (FIGURE 15), requiring a force of about 445 N (100 lb) to push the lid open (over centre) and about 550 N (125 lb) to close the lid. The considerable force required to open the iler lid was inconvenient for some operators. The lids were not equipped with weather stripping to prevent moisture entry. It is recommended that the tank lid opening and closing force requirement be reduced.

The front tank held 3200 L (88 bu) while the rear tank held 3316 L (92 bu).

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

Maneuverability: Because of the additional pivot point at the hitch between the applicator and the cultivator, the Flexi-coil air ow seeder, when attached to the cultivator, was difficult to manoeuvre while back ing up.

Monitoring: The test machine was not supplied with a material ow monitoring system. An indicator was visible from the tractor cab to monitor meter rotation. Material ow through the distribution tubes was not monitored. Because plugging of the distribution system was difficult to detect from the tractor seat, it is recommended that a ow monitoring device be provided as optional equipment.

Seed and Fertilizer Boots: Due to deformation of seed boot and eater, the manufacturer supplied stronger seed-boots after the spring seeding period. No seed boot or fertilizer boot plugging occurred during the evaluation period.

Cleaning: Access to the front meter required emptying of the front tank. The rear meter was accessible without emptying the tank. Tank side cleanout doors were provided for both tanks. However, the rear tank did not empty by gravity and required the material to be moved to the cleanout door. Because the cleanout doors were located about 100 mm (4 in) above the meters, a vacuum cleaner was required for thorough cleaning. Access to the tanks was possible through the tank iler openings by removal of the tank opening screens. The screens could be removed without tools.

Area Meter: No area meter was supplied with the Flexi-coil. 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 Flexi-coil applicator and John Deere cultivator were easily placed in transport position (FIGURE 16) in less than ve minutes. Dual hydraulic cylinders raised the cultivator wings to the upright position. The meter drive was conveniently engaged and disengaged hydraulically from the tractor seat. For extended transport at high speeds, the meter drive chain on the right hand applicator wheel should be removed. Access for chain removal was good.

The assembly towed well in transport position. Overall transport height and width were 4.3 m (14.1 ft) and 6.2 m (20.3 ft) respectively, requiring care when travelling on public roads.

EASE OF ADJUSTMENT

Lubrication: Lubrication was convenient with good access to all grease ttings. Eleven ttings on the applicator and seven on the cultivator required servicing. Two wheels on the applicator and eight on the cultivator required servicing. A servicing schedule was supplied in the operator’s manual.

Engine Servicing: The engine was positioned for convenient access. The recommended oil change interval for the engine was 100 hours. Engine fuel consumption was about 2.5 L/hr (0.55 gal/ hr). The engine could run about 24 hours on one iling of the 60 L (13 gal) tank.

Application Rate: Application rate for the front tank was easily changed by loosening a lock bolt and moving the adjustment slide controlling the amount of ute exposure (FIGURE 17). Moving the slide to the right from zero, along the ne scale, adjusted the meter for small grains in increments of 0.5 from 0 to 5. Moving the slide to the left, along the coarse scale, adjusted the meter for cereals in increments of 1, from 0 to 20.

Application rate for the rear meter was changed by loosening a lock bolt and adjusting a lever for the amount of gate opening above the conveyor belt in increments of 1, from 0 to 20.

Calibration charts in pounds per acre were shown in both the operator’s manual and a decal on the applicator.

Adjusting for precise seeding rates was difficult due to relatively large scale divisions. For example, in Tower rapeseed, each 0.5 scale increment changed the seeding rate by up to 6 kg/ha (5.3 lb/ac).
sizes presented in the tables are the maximum power takeoff rating tractor operating at 80% of maximum power on a level field. The values have been adjusted to include tractive efficiency and represent a duty cultivator, in light and heavy primary tillage. Tractor sizes to operate the Flexi-coil applicator and John Deere 1610 heavy tractor are presented in the tables for light and heavy primary tillage. The power requirements given are for the Flexi-coil applicator, with 107 m John Deere 1610 Cultivator in Light Primary Tillage.

### Tractor Size (Maximum Power Take Off Rating, kW) to Operate the Flexi-Coil Applicator, with 107 m John Deere 1610 Cultivator in Light Primary Tillage

<table>
<thead>
<tr>
<th>DEPTH (mm)</th>
<th>SPEED (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>50</td>
<td>65</td>
</tr>
<tr>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>100</td>
<td>113</td>
</tr>
<tr>
<td>125</td>
<td>138</td>
</tr>
</tbody>
</table>

### Tractor Size (Maximum Power Take Off Rating, kW) to Operate the Flexi-Coil Applicator, with 107 m John Deere 1610 Cultivator in Heavy Primary Tillage

<table>
<thead>
<tr>
<th>DEPTH (mm)</th>
<th>SPEED (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>50</td>
<td>61</td>
</tr>
<tr>
<td>75</td>
<td>109</td>
</tr>
<tr>
<td>100</td>
<td>158</td>
</tr>
<tr>
<td>125</td>
<td>207</td>
</tr>
</tbody>
</table>

### OPERATOR SAFETY

The Flexi-coil tank access ladder was convenient and safe. A safety handrail was provided beside the access ladder and along the upper walkway. The fan engine fuel shut-off was located on the side of the engine. After prolonged periods of use, the shut-off became very hot and difficult to shut off without some form of insulation between the operator’s hand and the engine. The engine ignition and electrical warning indicators, originally located on the engine, were relocated above the engine in a manufacturer’s mod cation (FIGURE 18). The engine exhaust system was located so that the operator had to reach over the exhaust to operate the ignition. It is recommended that modifications be made to insulate or protect both the engine shut-off and engine exhaust for improved operator safety.

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 4.8 m (15.7 ft) over farm land or over secondary roads. In Alberta and Manitoba, the neutral ground wire may be as low as 4.6 m (15 ft). The Flexi-coil cultivator with John Deere 10.7 m (35 ft) cultivator was 4.3 m (14.1 ft) high in transport position, permitting safe transport under power line power lines. On the other hand, transport height with the 11.9 m (39 ft) wide model of the same cultivator is 4.9 m (16.2 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 Flexi-coil with John Deere 1610 cultivator was 6.2 m (20.3 ft) wide in transport position. This necessitated caution when towing on public roads, over bridges and through gates. A slow moving vehicle sign was provided on the rear of the applicator for transport. Pins were provided to lock the cultivator wings in transport position. The depth cylinder could be locked in the raised position with the depth adjusting sleeve.

The Flexi-coil applicator, with John Deere 1610 cultivator, towed well at speeds up to 28 km/h (17 mph).

Centre section tire loads on the cultivator in transport position exceeded the Tire and Rim Association maximum load rating for 7.60 x 15, 6-ply tires by about 13 per cent. Applicator wheels exceeded the Tire and Rim Association maximum load rating for 18.4 x 26, 10-ply tires by about 45 per cent. This tire load could be unsafe at high transport speeds and therefore
prolonged transport with full applicator tanks should be avoided.

Total engine and fan noise level at the tractor hitch point was about 99 dbA. This increased the operator station noise level in most modern tractor cabs by only 2.3 dbA. For example, in one tractor cab, operator station noise level was 77.8 dbA with only the tractor operating and 80.1 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 Flexi-coil air ow seeder contained useful information on safety adjustments, maintenance, specifications, assembly and operation. A detailed parts list was also included. Metering calibration charts for various cultivator widths, calibrated in Imperial units, were included in the operator’s manual. Calibration charts were also printed on decals, which could be placed on the seeder for convenient field reference. A metric meter calibration was not included. It is recommended that the manufacturer consider supplying meter calibrations for all grains in SI units.

**DURABILITY RESULTS**

TABLE 4 outlines the mechanical history of the Flexi-coil air ow seeder with 1610 John Deere cultivator during 108 hours of field operation while processing about 770 ha (1900 ac). The intent of the test was evaluation of functional performance. An extended durability evaluation was not conducted.

**DISCUSSION OF MECHANICAL PROBLEMS**

**APPLICATOR**

Manufacturer’s Modifications: Manufacturer modifications performed during the evaluation period included modified fan engine mounting, relocation of fan engine electrical control box, exchange of fan pressure gauge with fan tachometer, heavier seed boots, altered fan drive shield and improved fan engine Air cleaner.

**Metering Flutes:** The front metering utes were damaged due to small rocks lodging between the rotating meter utes and the meter body. The utes were straightened and repaired and no further problems were encountered.

**CULTIVATOR**

Headers: Moisture in the distribution system resulted in a build-up of material inside both the primary and secondary headers (FIGURE 19). A small amount of material build-up did not affect material distribution adversely. However, continued build-up of material could have an effect. Operating the fan for a few minutes before seeding to remove the moisture should reduce material build-up.

**TABLE 4. Mechanical History**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>OPERATING HOURS</th>
<th>EQUIVALENT FIELD AREA (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPLICATOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-The meter operation indicator bulb filament broke and was replaced at</td>
<td>13, 27, 62</td>
<td>90, 190, 440</td>
</tr>
<tr>
<td>-The engine generator light vibrated out of the control box and was replaced at</td>
<td>34</td>
<td>249</td>
</tr>
<tr>
<td>-The gauge indicating fan static pressure became inoperative at</td>
<td>41</td>
<td>290</td>
</tr>
<tr>
<td>-Manufacturer’s modifications were made at</td>
<td>58, 82</td>
<td>415, 585</td>
</tr>
<tr>
<td>-The rear metering conveyor belt was adjusted at</td>
<td>82</td>
<td>585</td>
</tr>
<tr>
<td>-Two distribution hose ends pulled out of the fertilizer boots and were reinstalled at</td>
<td>105</td>
<td>750</td>
</tr>
<tr>
<td>-The front metering barrel was removed and the utes were straightened and re-welded at</td>
<td>108</td>
<td>770</td>
</tr>
<tr>
<td>-The primary and secondary headers were cleaned at</td>
<td>108</td>
<td>770</td>
</tr>
<tr>
<td>CULTIVATOR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-The sweeps working in applicator and cultivator wheels tracks were replaced at</td>
<td>54</td>
<td>385</td>
</tr>
<tr>
<td>-The depth stop adjustment bolt was replaced at</td>
<td>77</td>
<td>550</td>
</tr>
<tr>
<td>-All sweeps were replaced at</td>
<td>83</td>
<td>590</td>
</tr>
<tr>
<td>-Fertilizer banding boots and chisel points were installed at</td>
<td>88</td>
<td>639</td>
</tr>
<tr>
<td>-The right wing depth cylinder pin fell out and was replaced at</td>
<td>105</td>
<td>750</td>
</tr>
</tbody>
</table>

FIGURE 18. (A) Engine Ignition, (B) Engine Exhaust (C) Engine Fuel Shut Off.

APPENDIX I

SPECIFICATIONS

(A) AIR FLOW SEEDER
MAKE: Flexi coil Air Flow Seder
MODEL: AS
SERIAL NUMBER: 193L1
MANUFACTURER: Flexi coil Ltd
P O Box 1928
Saskatoon, Saskatchewan
S7K 2S5

DIMENSIONS:
-width 2780 mm
-length 5290 mm
-height 3100 mm
-maximum ground clearance 210 mm
-wheel tread 2245 mm

METERING SYSTEM:
-type externally fluted feed wheel
-front slide door over conveyor belt
-rear pneumatic conveyance through divider
-number of meters 2
-drive chain drive from right applicator wheel
-adjustment
-
-front
-coarse slide for exposure area over coarse flutes
-fine slide for exposure area over fine flutes
-rear varying gate opening above conveyor belt
-transfer to openers

TANK CAPACITIES:
-front 3208 L (88 bu)
-rear 3318 L (92 bu)
-Total 6526 L (180 bu)

FAN:
-type straight blade centrifugal
-maximum operating speed 3000 rpm
-drive triple V-belt

ENGINE:
-make Lombardini Air Cooled 4 Stroke Diesel
-model 904
-power rating 154 kW at 2540 rpm
-starting system 12 volt electric
-fuel tank capacity 60 L

WHEEL:
-singles 18 x 4 x 26, 10 ply

NUMBER OF LUBRICATION POINTS:
-11 grease fittings
-2 wheel bearings

HITCH:
-vertical adjustment range 155 mm in 6 positions

DEPTH CONTROL:
-hydraulic

FRAME:
-cross section 100 mm square tubing, 64 mm thickness

TIRES:
-8, 760L x 15, 6 ply implement

NUMBER OF LUBRICATION POINTS:
-7 grease fittings
-6 oiling points

HYDRAULIC CYLINDERS:

OPTONAL EQUIPMENT:

SPECIFICATIONS

USA
Des Moines, Iowa 50306

MANUFACTURER:
SERIAL NUMBER:
MODEL:
MAKE:

CONVERSION TABLE

1 hectare (ha) = 2.5 acres (ac)
1 kilometre/hour (km/h) = 0.6 miles/hour (mph)
1 meter (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 mass (lb)
1 newton (N) = 0.22 pounds force (lb)
1 litre (L) = 0.26 gallons (gal)
1 kilogram/hectare (kg/ha) = 0.9 pounds/acre (lb/acre)
1 kilogram/hectolitre (kg/L) = 0.8 pounds/bushel (bu/bu)
1 kilonewton/metre (kN/m) = 70 pounds force/foot (lb/ft)

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