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Evaluation Report 532

Versatile Trans-Axial 2000 Pull-Type Combine

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

VERSATILE TRANS-AXIAL 2000 PULL-TYPE COMBINE

MANUFACTURER AND DISTRIBUTOR:

Versatile Farm Equipment Co.
1260 Clarence Avenue
Winnipeg, Manitoba
R3T 1T3
Phone: (204) 284-6100

RETAIL PRICE:

$80,400.00 (March, 1987, f.o.b. Humboldt, Sask., Melroe 388 pickup, 23.1 x 26 R3 diamond tread tires).

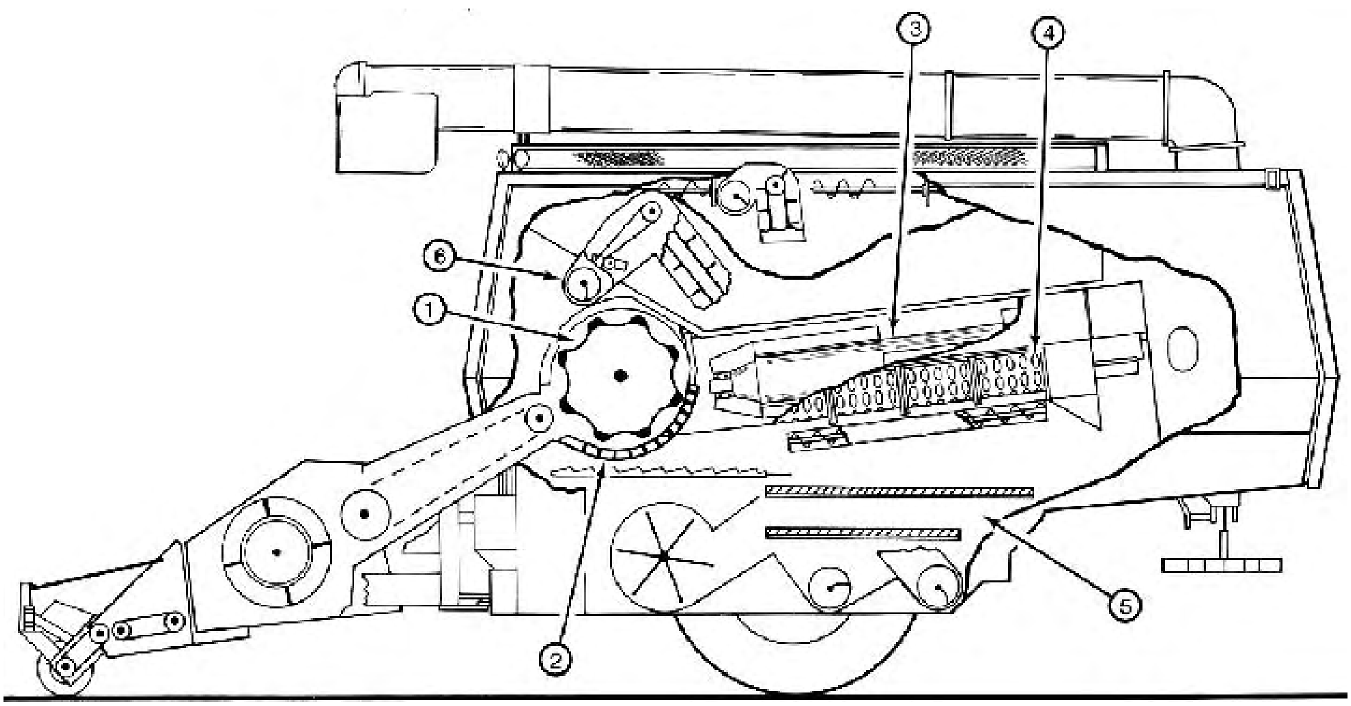

FIGURE 1. Versatile Trans-Axial 2000: (1) Cylinder, (2) Concave, (3) Separating Rotors, (4) Rotor Grates, (5) Cleaning Shoes, (6) Tailings Return.

SUMMARY AND CONCLUSIONS

Capacity: In capacity tests MOG feedrate* at 3% total grain loss was 485 lb/min (13.2 t/h) in Harrington barley, and ranged from 790 lb/min (21.6 t/h) in Columbus wheat to 915 lb/min (25 t/h) in Katepwa wheat.

At 3% total grain loss, the Versatile Trans-Axial 2000 had about 1.15 times the capacity of the PAMI Reference II combine in barley and 1.20 to 1.40 times the Reference II combine's capacity in wheat.

Quality of Work: Pickup performance was good in all crops. It picked cleanly and delivered the material smoothly under the table auger. Feeding was good. The feeder was very aggressive which caused some grain loss. Stone protection was good. The stone trap prevented hard objects from entering the cylinder. Threshing was very good. In all crops and conditions encountered unthreshed loss was low over the entire operating range. Grain damage was also low.

Separation of grain from straw was good. However, crop did not feed smoothly into the rotors until modifications were made by the manufacturer. In barley, rotor loss was high even at low feedrates. In wheat, rotor loss was high at low feedrates, but remained about the same or decreased at high feedrates. The high rotor loss at low feedrates in both wheat and barley made it impossible to harvest at a total loss less than 1%.

Cleaning shoe performance was fair. Shoe loss limited combine capacity in all crops. Although shoe loss was low at low feedrates in wheat and barley, loss increased rapidly at high feedrates. In canola and flax crops shoe loss was high even at low feedrates. The grain sample was clean in all crops. The return overloaded in canola and flax crops when trying to minimize shoe loss.

*MOG Feedrate (Material-Other-than-Grain Feedrate) is the mass of straw and chaff passing through the combine per unit of time.

Grain handling was good. The 215 Imperial bushel (7.8 m³) grain tank filled evenly and completely in all crops. Positioning the unloading auger was convenient. Unloading was slow taking 190 seconds to unload a full tank. The grain tank did not clean out completely.

Straw spreading was fair. Straw was spread over about 20 ft (6.1 m) with more straw thrown in the center.

Ease of Operation and Adjustment: Ease of hitching to the Versatile Trans-Axial 2000 was good. The comfort, visibility and convenience of operating depended on the tractor used. The Versatile 856 used in the tests was well suited to the Trans-Axial 2000.

Combine lighting was poor. Additional lighting from the tractor was required. Also, the light for unloading was insufficient and no light was provided for inside the grain tank.

Handling was good. The combine was easy to place in transport or field position with the aid of tractor hydraulics. The combine towed well at speeds up to 20 mph (32 km/h).

Ease of machine cleaning was poor. Chaff lodged in hard-to-clean places in the combine and large amounts of chaff collected on the exterior of the combine. Cleaning the combine was time consuming.

Ease of lubrication was fair. Many fittings required daily service. Some fittings were difficult to reach. Ease of maintenance was good.

Power Requirements: The manufacturer recommended a minimum tractor size of 130 PTO hp (97 kW). Power take-off input power alone was 125 hp (93.3 kW) when operating at capacity in Columbus wheat. Much more power would be required for harder threshing conditions and for pulling a loaded combine in hills. PAMI suggests that a tractor with at least 175 PTO hp (130.5 kW) is required for most harvesting conditions.

Operator Safety: The operator's manual emphasized operator safety. All moving parts were well shielded. The Versatile

Trans-Axial 2000 was safe to operate if normal safety precautions were followed.

Operator's Manual: The operator's manual was good. It contained useful information on safety, servicing, lubrication, setting and specifications.

Mechanical History: Several mechanical problems occurred throughout the test.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifications to eliminate plugging between the cylinder and separating rotors.
2. Modifications to ensure complete emptying of the grain tank.
3. Improving lighting especially for unloading and viewing inside the grain tank.
4. Modifications to improve the ease of adjusting and viewing concave clearance.
5. Modifications to prevent large amounts of chaff and debris from collecting in and on the combine.
6. Making changes to the operator's manual to correct errors in referencing and the specifications section.
7. Modifications to prevent case failure of the PTO driven gearbox.
8. Strengthening the rasp bar support hubs to prevent bending.
9. Mounting the components in the monitor control box more securely.
10. Wiring the cylinder speed and fan speed controls correctly.
11. Modifications to prevent the grain tank from contacting the tailings auger drive sheave.
12. Using bolts with more durable heads.

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Project Technologist: W.A. Beckett

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. The transition plate was modified on all production combines as part of a factory program during the 1986 season.
2. This is under design consideration.
3. This is under design consideration.
4. We are investigating an improved adjuster. However, the Trans-Axial concept does not require fine adjustment to the concave.
5. No changes are planned at this time.
6. The operator's manual will be reviewed prior to a new production release.
7. The gearbox material has been improved on 1986 models.
8. We suspect this happened when the plugging occurred at the transition between the cylinder and separating rotors. (See item no. 1).
9. This is under review.
10. This occurred only with the combine tested by PAMI. The control box wiring was changed during production improvements and was shipped to PAMI some time after the combine was shipped. We were, therefore, unable to make the wiring change on the combine.
11. This has been modified for 1986 and future production. All 1985 machines have been updated.
12. The bolt specifications are being reviewed.

MANUFACTURER'S ADDITIONAL COMMENTS

1. **Straw Spreading:** Spread width is meaningless unless compared with another combine in the same condition. Versatile owners consistently report a better spread job than their second combine even though it may be equipped with a straw chopper.
2. **Power Requirements:** Power and capacity are directly related on the Trans-Axial 2000. This does not mean an owner with a smaller tractor cannot achieve satisfactory performance. Many operators on level land are using two-wheel tractors with 130 to 135 PTO horsepower (97 to 101 kW), and are harvesting more grain per day than with the same power on conventional combines.
3. **Capacity in Barley:** We feel the test results in barley do not represent the machine capacity since the test was conducted in a barley crop of very tow moisture content and unusual MOG/G ratio. Our reports from the field indicate a much higher capacity in barley, especially in high MOG/G conditions.

GENERAL DESCRIPTION

The Versatile Trans-Axial 2000 is a power take-off driven pull-type combine. It has a single transverse mounted cylinder, two longitudinally mounted rotors and a cleaning shoe. The cylinder is an open design, equipped with eight rasp bars. The alternate bars have opposite angled ribs. The main concave is a bar and wire design. The separating rotors are a closed tube design with fin sections staggered about the tube. The rotor grates are formed metal. The cleaning fans are dual undershot paddle fans. The chaffer and cleaning sieves move in opposed motion. Both the chaffer and cleaning sieves are adjustable lip design.

Crop is fed to the centre of the cylinder where threshing begins. Grain is separated as the crop travels over the main concave. The crop flow continues around the cylinder where it is divided by vanes above the cylinder. The vanes direct the crop to the outer ends of the cylinder where it passes over two small separating concaves, which flank the main concave. As the crop leaves the cylinder the two streams are fed into the longitudinally mounted rotors. Final separation occurs as the rotors spiral the crop over the rotor grates. Separated material is fed to the cleaning shoe by a grain pan under the cylinder and augers under the rotors. Tailings are returned to the cylinder.

The test machine is equipped with a Melroe 388, 10 ft (3.0 m), two roller draper pickup and transfer drapers, as well as the standard equipment listed in the specifications.

The separator drive is controlled by the tractor power take-off clutch. The header and unloading auger drives are engaged by electro-magnetic clutches controlled from the combine control box mounted in the tractor cab. Pickup speed, cylinder speed and cleaning fan speed are also electrically controlled from the combine control box. Header height, unloading auger swing and hitch pole positioning are controlled by the tractor hydraulics. Only the rear concave clearance can be adjusted. The clearance is varied by adjusting draw bolts with wrenches. The sieves are adjusted with levers at the rear of the shoe.

The test combine differs slightly from models currently available. Many of the changes to the cylinder rasp bars, rotor fins, rotor grates, and drives are described in Interim Report #499. These changes were available as updates for many of the previous machines. In addition to these changes, the test combine has a new monitor control box and wiring harness, a modified PTO driveline and a relocated hydraulic pickup drive.

SCOPE OF TEST

The Versatile Trans-Axia12000 was operated for about 90 hours while harvesting about 753 ac (304 ha) of various crops. The crops and conditions are shown in TABLES 1 and 2. During the harvest, the machine was evaluated for rate of work, quality of work, ease of operation and adjustment, operator safety, and suitability of the operator's manual. Extended durability testing was not conducted. The mechanical history was recorded.

RESULTS AND DISCUSSION

TERMINOLOGY

MOG, MOG Feedrate, Grain Feedrate and MOG/G Ratio: A combine's performance is affected mainly by the amount of straw and chaff it is processing and the amount of grain or seed it is processing. The straw, chaff, and plant material other than the grain or seed is called MOG, which is an abbreviation for "Material-Other-than-Grain". The quantity of MOG being processed per unit of time is called "MOG Feedrate". Similarly, the amount of grain being processed per unit of time is the "Grain Feedrate".

The MOG/G ratio, which is the MOG Feedrate divided by the Grain Feedrate, indicates how difficult a crop is to separate. For example, MOG/G ratios for prairie wheat crops may vary from 0.5 to

1.5. In a crop with a 0.5 MOG/G ratio, for every 100 lbs (45.4 kg) of grain harvested, the combine has to handle 50 lbs (22.7 kg) of straw. However, in a crop with a 1.5 MOG/G ratio for a similar 100 lbs (45.4 kg) of grain harvested the combine now has to handle 150 lbs (68.1 kg) of straw –- 3 times as much. Therefore, the higher the MOG/G ratio, the more difficult it is to separate the grain.

TABLE 1. Operating Conditions

Crop	Variety	Average Yield		Windrow Width		Hours	Field Area	
		bu/ac	t/ha	ft	m		ac	ha
Barley	Argyle Bonanza Herrington	65 60 60	3.5 3.2 3.2	24 24, 26 25	7.3 7.3, 7.9 7.6	1 13 2	5 93 12	2 38 5
Canola	Wester	40	2.3	18, 22, 24	5.5, 6.7, 7.3	17	100	40
Flax	Dufferin	15	0.9	24	7.3	5	46	18
Rye	Musketeer	35	2.2	21	6.4	17	110	44
Wheat	Columbus Katepwa	40 35	2.7 2.4	25, 28, 30 30, 42	7.6, 8.5, 9.1 9.1, 12.8	12 235	146 239	60 97

TABLE 2. Operation in Stony Conditions

Field Conditions	Hours	Field Area	
		ac	ha
Stone Free	22	173	70
Occasional Stones	58	495	200
Moderately Stony	10	85	34
Total	90	753	304

Grain Loss, Grain Damage and Dockage: Grain loss from a combine can be of two main types: Unthreshed Loss, consisting of grain left in the head and discharged with the straw and chaff, or Separator Loss which is free (threshed) grain discharged with the straw and chaff. Separator Loss can be further defined as Shoe Loss and Walker (or Rotor) Loss depending where it came from. Loss is expressed as a percentage of the total amount of grain being processed.

Damaged or cracked grain is also a form of grain loss. In this report the cracked grain is determined by comparing the weight of actual damaged kernels to the entire weight of a sample taken from the grain tank.

Dockage is determined by standard Grain Commission methods. It consists of large foreign particles and of smaller particles that pass through a screen specified for that crop. It is expressed as a percentage of the weight of the total sample taken.

Capacity: Combine capacity is the maximum rate at which a combine, adjusted for optimum performance, can process crop material at a certain total loss level. PAMI expresses capacity in terms of MOG Feedrate at 3% total loss. Although MOG Feedrate is not as easily visualized as Grain Feedrate, it provides a much more consistent basis for comparison. A combine's ability to process MOG is relatively consistent even if MOG/G ratios vary widely. Three percent total loss is widely accepted in North America as an average loss level that provides an optimum trade-off between work accomplished and grain loss. This may not be true for all combines nor does it mean that they cannot be compared at other loss levels.

Reference Combine: It is well recognized that a combine's capacity may vary greatly due to differences in crop and weather conditions. These differences make it impossible to directly compare combines not tested in the same conditions. For this reason, PAMI uses a reference combine. The reference combine is simply one combine that is tested along with each combine being evaluated. Since the test conditions are similar, each test combine can be compared directly to the reference combine to determine a relative capacity or "capacity ratio". This capacity ratio can be used to indirectly compare combines tested in different years and under different conditions. As well, the reference combine is useful for showing how crop conditions affect capacity. For example, if the reference combine's capacity is higher than usual, then the capacity of the combine being evaluated will also be higher than normally expected.

For 10 years PAMI has used the same reference combine. However, capacity differences between the reference combine and some of the combines tested have become so great that it has become difficult to test the reference combine in the conditions suitable for the evaluation combines. PAMI has changed its reference combine to better handle these conditions. The new reference combine is a larger conventional combine that was tested in 1984 (see PAMI report #426). To distinguish between the reference combines the new reference will be referred to as Reference II and the old reference as Reference I.

RATE OF WORK

Capacity Test Results: The capacity test results for the Versatile Trans-Axial 2000 are summarized in TABLE 3.

The performance curves for the capacity tests are presented in FIGURES 2 to 4. The curves in each figure show the effect of increased feedrate on rotor loss, shoe loss, unthreshed loss and total loss. The graphs can also be used to determine combine capacity at loss levels other than 3%.

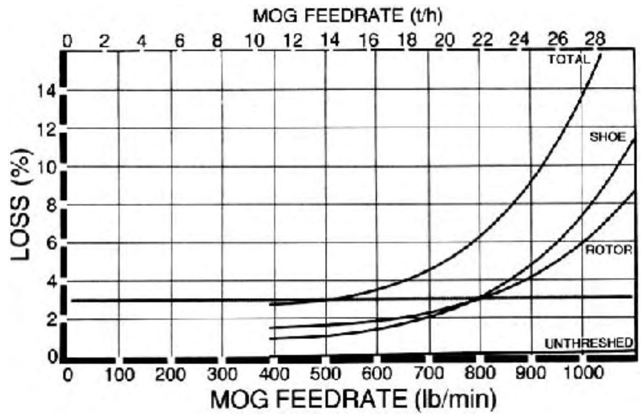

FIGURE 2. Grain Loss in Harrington Barley.

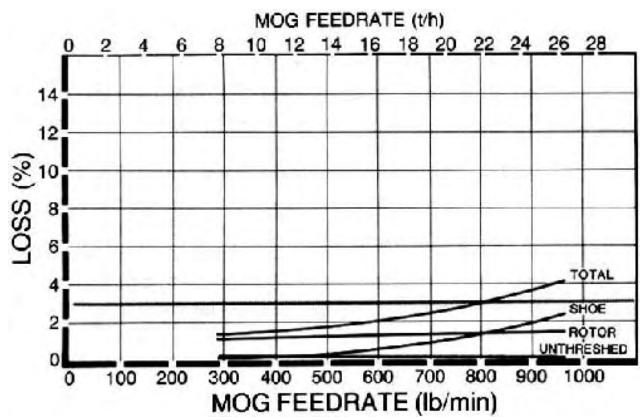

FIGURE 3. Grain Loss in Columbus Wheat.

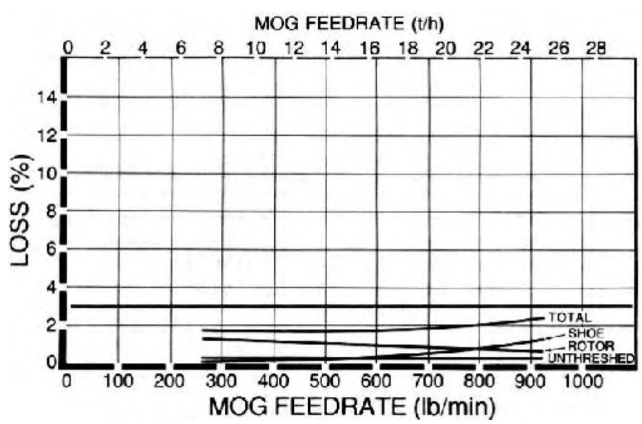

FIGURE 4. Grain Loss in Katepwa Wheat.

The Harrington barley crop used for the test was from a uniform stand and was laid in well formed side-by-side double windrows. The

TABLE 3. Capacity of the Versatile Trans-Axial 2000 at a Total Loss of 3% of Yield

Crop Conditions									Results							
		Width of Cut		Crop Yield		Moisture Content			MOG Feedrate		Grain Feedrate		Grain Cracks %	Dockage %	Foreign Material	Loss Curve
Crop	Variety	ft	m	bu/ac	t/ha	Straw %	Grain %	MOG/G	lb/min	t/h	bu/h	t/h				
Barley	Harrington	56	17.1	54	2.9	5	9.8	0.62	485	13.2	980	21.4	0.4	0.3	0.3	2
Wheat	Columbus	56	8.9	40	2.7	7	15.1	1.20	790	21.6	660	18.0	1.9	5.0	3.6	3
Wheat	Katepwa	29	8.9	49	3.3	8	14.2	1.23	915	25.0	740	20.2	1.7	2.5	1.2	4

crop was mature and both the grain and straw were very dry. The grain threshed easily and the awns broke off readily. Straw break-up was quite high. The grain yield was slightly below average but the straw was short which resulted in a low MOG/G ratio. The low MOG/G ratio meant that high grain feedrates accompanied relatively low MOG feedrates.

In this barley crop, the capacity of the Versatile Trans-Axial 2000 at a 3% total loss was 485 lb/min (13.2 t/h) MOG. This was lower than expected for this type of combine even though the accompanying grain feedrate was quite high. As well, losses were high (2.5%) for the lowest feedrates tried. Had lower feedrates been attainable the total loss would have been lower but likely not below 1.5%.

Both wheat crops were from uniform stands. The Columbus was laid in well formed side-by-side double windrows while the Katepwa was in a single well formed windrow. The crops were mature. The straw was dry for both crops. In Columbus the grain was almost dry and in Katepwa it was dry. In both crops the grain threshed easier than Neepawa wheat. The straw did not break up readily. Although the grain yield was slightly above average, the very long straw resulted in high MOG/G ratios for both crops. The high MOG/G ratios meant that low grain feedrates accompanied the MOG feedrates.

In wheat, the capacity at 3% total loss ranged from 790 lb/min (21.6 t/h) in Columbus to 915 lb/min (25.0 t/h) in Katepwa. While total loss limited capacity in Columbus, in Katepwa capacity was limited by the available power. Although capacity at 3% loss was high, total loss did not drop below 1.5 to 2.0% at any of the lower feedrates.

Average Workrates: TABLE 4 indicates the average workrates obtained in each crop over the entire test season. These values are considerably lower than the capacity test results in TABLE 3. This is because the results in TABLE 3 represent instantaneous rates while average workrates take into account operating at less than optimum feedrates, variable crop and field conditions, availability of grain handling equipment, and differences in operating habits. Most operators could expect to obtain average rates in this range, while some daily rates may approach the capacity test values. The average workrates should not be used to compare combines. The factors, which affect workrates are too variable and cannot be duplicated for all combine tests.

TABLE 4. Average Workrates.

		Average Yield		Average Workrates			
Crop	Variety	bu/ac	t/ha	ac/h	ha/h	bu/ac	t/h
Barley	Argyle	65	3.5	5.0	2.0	325	7.1
	Bonanza	60	3.2	7.2	2.9	430	9.4
	Herrington	60	3.2	6.0	2.4	360	7.9
Canola	Westar	40	2.3	5.9	2.4	235	5.3
Flax	Dufferin	15	0.9	9.2	3.7	140	3.6
Rye	Musketeer	35	2.2	6.5	2.6	230	5.9
Wheat	Columbus	40	2.7	12.3	5.0	490	13.4
Wheat	Katepwa	35	2.4	10.4	4.2	365	10.0

Comparing Combine Capacities: The capacity of combines tested in different years or in different crop conditions should be compared only by using the PAMI reference combines. Capacity ratios comparing the test combine to the reference combine are given in the following section. For older reports where the ratio is not given, a ratio can be calculated by dividing the MOG feedrate listed in the capacity table by the corresponding MOG feedrate of the reference combine listed in APPENDIX II for that particular crop.

Once capacity ratios for different evaluation combines have been determined for comparable crops they can be used to approximate capacity differences. For example, if one combine has a capacity ratio of 1.2 times the reference combine and another combine has a capacity ratio of 2.0 times the reference combine, then the second combine is about 67% larger ((2.0 - 1.2) / 1.2 x 100 = 67%).

A test combine can also be compared to the reference combine at losses other than 3%. The total loss curves for the test combine and reference combine are shown in the graphs in the following section. The shaded bands around the curves represent 95% confidence belts. Where the bands overlap, very little difference in capacity exists; where the bands do not overlap a significant difference can be noticed.

PAMI recognizes that the change to the new Reference II combine may make it difficult to compare test machines, which were compared only to the older Reference I. To overcome this, a capacity ratio comparing the test combine to Reference I is also given in the Summary Chart on the last page of the report. This ratio is based on two years of tests, which indicate that Reference II has about 1.50 to 1.60 times the capacity of Reference I in wheat and about 1.40 to 1.50 times Reference I's capacity in barley.

Capacity Compared to Reference Combine: Capacity of the Versatile Trans-Axial 2000 was slightly greater than that of the PAMI Reference II combine in barley and wheat crops. At 3% total loss the Versatile had about 1.15 times the capacity of the Reference II combine in Harrington barley, about 1.20 times its capacity in Columbus wheat, and about 1.40 times its capacity in Katepwa wheat. FIGURES 5 to 7 compare the total loss of both combines.

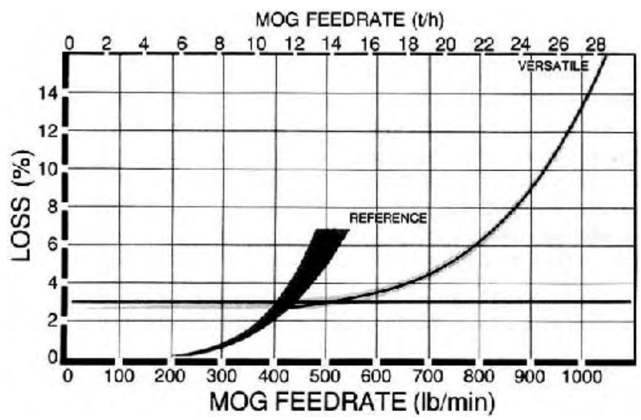

FIGURE 5. Total Grain Loss in Harrington Barley.

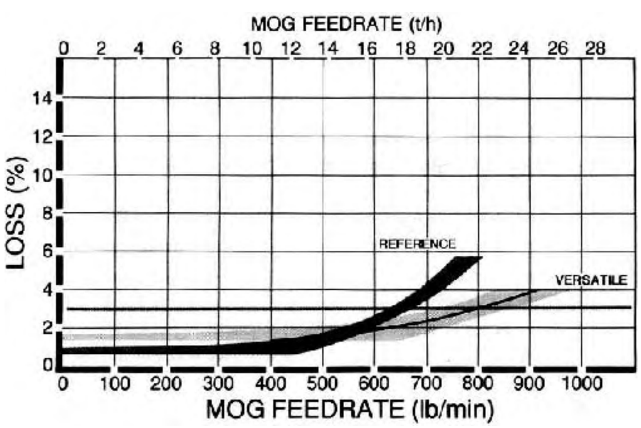

FIGURE 6. Total Grain Loss in Columbus Wheat.

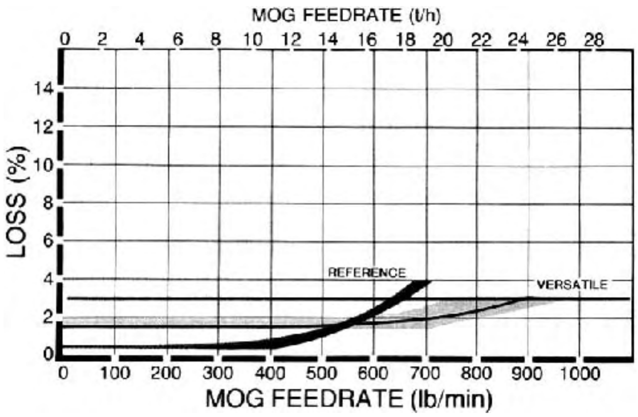

FIGURE 7. Total Grain Loss in Katepwa Wheat.

QUALITY OF WORK

Picking: Pickup performance was good.

The pickup was normally operated at a 30 to 45 degree angle to the ground. The picking speed was set slightly faster than ground speed with the teeth just touching the ground. With these settings all crops in well supported windrows were picked cleanly at speeds up to 6 mph (9.6 km/h). In poorly supported windrows the pickup was run much faster than ground speed and the picking angle reduced. In these hard to pick conditions pickup loss often increased noticeably at speeds over 4 mph (6.4 km/h). In easy-to-thresh crops such as canola, shelling was low, if the windguard was removed. A few small stones were picked.

Once picked, the transfer drapers conveyed all crops smoothly under the table auger. No wrapping occurred and the crop was stripped cleanly from the drapers.

The pickup was too narrow for picking some side-by-side double windrows and for picking around corners.

Feeding: Feeding was good.

To ensure uniform feeding to the cylinder and rotors, it was necessary to centre single windrows with the feeder opening. The table auger and feeder conveyor were very aggressive and seldom plugged. The aggressive action provided smooth crop flow in nearly all crops. The table auger wrapped in tough flax straw. Changing the table auger finger timing did not greatly reduce this wrapping. The aggressive action of the feeder conveyor either threshed a lot of grain upon initial contact or conveyed grain from the return down the feeder house. The threshed grain was then thrown out of the header by the table auger. It is recommended that the manufacturer consider modifications to prevent grain loss from the header.

Stone Protection: Stone protection was good.

The stone trap was most effective if emptied regularly to prevent grain and dirt from hardening in the “pocket”. The stone trap collected most stones and roots, which were driven into the pocket when contacted by the cylinder. Hard objects up to 4 in (102 mm) in diameter were often found in the trap. Some stones and roots did go through the machine but no damage occurred.

Threshing: Threshing was very good.

In all crops, cylinder speeds (rpm) similar to smaller cylinders were used. These speeds and the large diameter cylinder produced higher than normal threshing bar speed, which helped maintain smooth crop flow into and around the cylinder. However, the large opening at the front of the cylinder allowed wads of crop to be taken in which caused the cylinder to plug on three occasions.

In all crops, the higher than normal threshing bar speed and the contact of the cylinder with crop all the way around the cylinder resulted in very low unthreshed loss over the entire operating range. Rear concave adjustment did not greatly affect threshing performance. It did, however, affect separation, rotor loading and shoe loading.

Grain damage measured in the clean grain sample was low for all crops. Using higher cylinder speeds or operating at low feedrates increased grain cracks. Concave clearance did not affect grain damage. The settings PAMI found to give the most suitable performance are shown in TABLE 5.

Separating: Separation was good.

In rye and barley crops, material often bunched at the transition between the cylinder and rotors (FIGURE 8). The plugging often only occurred on one side and went undetected until the cylinder began to plug. Feeding between the cylinder and rotor was greatly improved when the manufacturer modified the transition plate. The risers protruding through the plate were removed and the slots covered. As well, the fronts of the transition plates were raised flush with the rear bar of the side concaves. It is recommended that the manufacturer consider modifications to eliminate plugging between the cylinder and rotors.

TABLE 5. Crop Settings.

Crop Settings										
Crop	Cylinder Speed	Rear Concave Clearance		Chaffer Sieve Setting		Chaffer Extension Setting		Cleaning Sieve Setting		Fan Speed
	rpm	in	mm	in	mm	in	mm	in	mm	rpm
Barley	810	0	0	7/8	22	3/4	19	3/8	10	800-900
Canola	680	3/4	19	1/2-5/8	13-16	1/2	13	1/8-3/16	3-5	450-550
Flax	910	0	0	5/8	16	1/2	13	1/8	3	52
Rye	700	1/4	6	5/8	16	5/8	16	3/16	5	700
Wheat	860	0	0	15/16	24	1	25	1/4	6	850-900

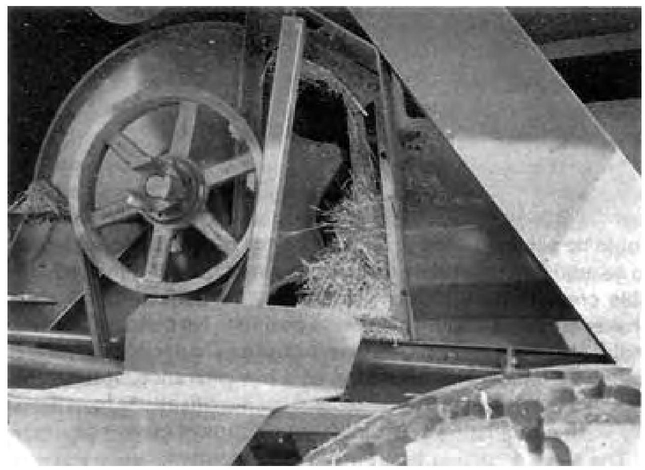
FIGURE 8. Plugging between the Cylinder and Rotor.

In barley, no combination of cylinder speed or rear concave clearance reduced rotor loss to less than 1% of yield at the lower feedrates. At high feedrates rotor loss increased rapidly and became a large part of the total loss. Similarly, in wheat, adjustments did not reduce rotor loss to less than 1% at the lower feed-rates. Rotor loss, in wheat, did however, remain the same or decrease slightly as feedrate increased. This resulted in rotor loss being a small part of the total loss at capacity.

The settings used for the crops encountered are shown in TABLE 5.

Cleaning: Cleaning shoe performance was fair.

Windrow feeding and concave clearance affected the uniformity of the crop delivered to the shoe. Driving off centre in single windrows caused uneven side-to-side loading. Wide rear concave clearance resulted in heavier shoe loading from the separating rotors. This caused light loading in the centre of the shoe and heavy loading on the outer edges. Centre feeding windrows and close rear concave clearance resulted in the most uniform shoe loading for most crops.

Generally the shoe settings suggested in the operator’s manual produced low shoe loss in wheat and barley at low and medium feedrates. However, shoe loss increased rapidly at higher feed-rates and limited capacity. PAMI found that using higher fan speeds and larger chaffer openings reduced shoe loss at higher feedrates without increasing shoe loss at low feedrates. In one test in Columbus wheat, which is not shown, using lower settings resulted in a capacity decrease of about 100 lb/min (2.7 t/h). Even using higher fan speeds and larger chaffer openings did not prevent shoe loss from limiting capacity in all wheat and barley crops.

In canola and flax, where it is desirable to operate at very low loss (less than 1.5%), no combination of settings were able to maintain losses lower than 1.5 to 2.0% of the yield. Settings which reduced losses below this level caused the tailings return to plug.

In all crops and conditions encountered, the settings suitable for minimizing shoe loss also provided a clean grain sample. The settings used in the crops encountered are listed in TABLE 5.

Clean Grain Handling: Grain handling was good.

The open grain tank filled evenly and completely in most dry crops although, in tough grain the corners did not fill. The grain tank held about 215 bu (7.8 m³) of dry wheat.

The unloading auger was hydraulically positioned to the left, rear or right. It had ample reach and clearance for all trucks and trailers encountered (FIGURE 9). The grain discharged in a compact stream, unloading a full tank of dry wheat in about 190 seconds. This was slow. When the unloading auger was shut off before it was empty, grain leaked from the end. In most crops the grain tank did not empty completely as grain bridged in the corners. It is recommended that the manufacturer consider modifications to ensure complete emptying of the grain tank.

FIGURE 9. Unloading.

Straw Spreading: Straw spreading was fair.

The straw from the Versatile Trans-Axial 2000 was broken less than from most rotaries but more than from conventional combines. As a result, additional chopping was not required.

The straw spreaders spread the straw over about 20 ft (6.1 m) directly behind the combine. The spread was uneven with a ridge of straw formed in the centre (FIGURE 10). PAMI installed solid disks, just slightly smaller than the bat diameter, on the bottom of each spreader. This improved the spread and uniformity slightly, and also spread some of the chaff.

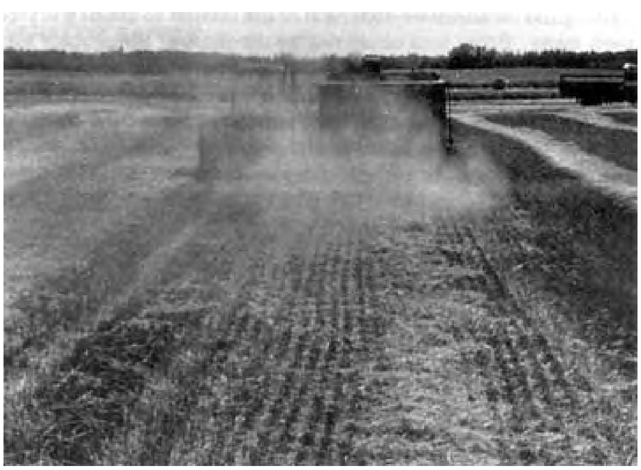

FIGURE 10. Typical Straw Spread Pattern.

EASE OF OPERATION AND ADJUSTMENT

Hitching: Ease of hitching was good. Initial hook-up took one person about a day. The control box had to be mounted in the tractor cab and all necessary wires routed. A hitch extension and safety chain had to be installed on the drawbar. The PTO drive shaft had to be aligned and the hitch pole adjusted to provide clearance between the tractor tires and the windrow.

The tractor had to have a 1.75 in (45 mm) splined, 1000 rpm, power-take-off, a 12V negative ground electrical system with at least a 75 amp alternator, and three hydraulic circuits.

Operator Comfort: Operator comfort and visibility depended on the tractor used.

The Versatile 856 tractor was well suited to the Versatile Trans-Axial 2000 combine. The air suspension, swivel seat and easily accessible controls made operating comfortable and convenient. The windrow was clearly visible as it entered the header. The grain unloading and the truck were easy to see while unloading on the left, but the grain was not visible when unloading to the right and to the rear.

Instruments: The instrumentation for the Versatile Trans-Axial 2000 was very good.

The instruments were located on a control box mounted in the cab (FIGURE 11). All important shaft speeds were monitored, as well as acres harvested, acres/hours harvested, and ground speed. These were displayed in metric or imperial units. The ability to display cylinder speed as well as ground speed or PTO speed was very convenient.

FIGURE 11. Combine Control Box and Grain Loss Monitor.

The monitor readout was clearly visible during the day and at night.

Controls: The controls on the cab mounted combine control box (FIGURE 11) were very good.

Switches engaged the electro-magnetic clutches for the header drive and unloading auger drive. Switches also controlled cylinder, fan and pickup speed. All switches were convenient to use. All controls except for pickup speed responded adequately. Pickup speed change was too slow for variable crop conditions.

The separator was engaged by the tractor PTO clutch. The tractor hydraulics controlled header height, unloading auger position and aided in putting the combine into field or transport position.

Loss Monitor: The grain loss monitor was not evaluated.

Four sensor pads were located at the rear of the chaffer. The pads could be adjusted from next to the chaffer to about 6 in (150 mm) away. Rotor loss could not be monitored. Since rotor loss was often quite high it would have been beneficial to monitor it.

For all grain loss monitors the grain loss readings are meaningful only if compared to actual losses observed behind the combine.

Lighting: Lighting supplied by the combine, for nighttime harvesting was poor.

The two work lights shining forward were insufficient and additional lighting supplied by the tractor was essential for proper forward and rearward lighting. No light was supplied for inside the grain tank. The light for unloading was ineffective. It is recommended that the manufacturer consider improving lighting especially for unloading and illuminating the grain tank.

Two warning flashers and two tail lights were provided to aid in safe road transport.

Handling: Handling was good, but depended mostly on the tractor used.

With the hitch pole set in the mid-position there was adequate clearance between the outside of the dual wheels on the Versatile 856 and the windrow, for windrow spacing of 20 ft (6.1 m). It was easy to pick around most windrow corners once familiar with how the combine followed the articulating tractor.

The Versatile Trans-Axial 2000 was easily placed into transport or field position using the tractor hydraulics. The combine transported well at speeds up to 20 mph (32 km/h). During transport caution was required as the wide combine made it difficult for the operator to see traffic approaching from the rear.

Adjustments: Ease of adjusting the combine components was good.

Pickup speed, fan speed and cylinder speed could be easily adjusted from the tractor cab. The table auger, concave, and sieve adjustments were located on the machine.

Table auger clearance and auger finger timing were easy to adjust and once set seldom had to be readjusted. Concave adjustment was slow and inconvenient. Only the rear of the concave could be adjusted. The draw bolts on the rear of the concave had to be adjusted separately using large wrenches (24 mm or adjustable crescent). Adjustment could only be done with the shoe shaker arms in the furthest forward position. No concave position indicators were provided. Therefore, the cylinder access panels had to be removed to gauge the concave clearance. It is recommended that the manufacturer consider modifications to improve the ease of adjusting and viewing the concave clearance.

The sieve adjusting levers were easy to adjust.

Field Setting: Ease of adjusting the Versatile Trans-Axial 2000 to suit crop conditions was fair.

Threshing was easy to set for in all crops. Very little unthreshed grain was found even in tough conditions. Unthreshed loss was easy to check since there was no straw chopper and the straw spreaders were easy to remove.

Separation was difficult to set for. In many conditions no combination of cylinder speed or rear concave clearance reduced rotor loss to less than 1% at the low and medium feedrates. Checking rotor loss was very difficult even with the straw spreaders removed. Both the rotor and shoe effluent came from the machine mixed together. This made is impossible to identify rotor loss from shoe loss. Generally, however, grain loss was much heavier under the mounds of straw from each rotor. The difference in loss between that under the two mounds of straw and the loss beside them was attributed to rotor loss.

Setting the shoe was also difficult. Shoe loss was not easy to see because of the mixing of the shoe and rotor effluent. It was also difficult to see what was happening on the chaffer because the material came off the tailings section in a “rooster tail”.

The return tailings could not be easily sampled. The bottom access door could be left open for checking but could not be easily or safely closed while operating.

Unplugging: Ease of unplugging was fair. Although the table auger and feeder seldom plugged the unplugging bar was heavy and inconvenient to use.

The cylinder seldom plugged, however, when it did, unplugging was difficult and time consuming. Slugs could not be cleared by lowering the concave and turning the cylinder backwards. The feeder house had to be tilted away from the combine (FIGURE 12) and the slug cleared by hand. Re-attaching the feeder house was difficult and could not be done alone.

When the tailings plugged, material wedged between the auger flighting and elevator sprocket, and was difficult to remove.

FIGURE 12. Feeder House Tilted Forward.

Machine Cleaning: Ease of cleaning the Versatile Trans-Axial 2000 was poor.

Even though many internal components were easily accessible, cleaning was time consuming. Crop material packed behind the cylinder strippers, above the cylinder housing and in a few other hard-to-clean places inside the combine. Not only was the material hard to clean but also it was a fire hazard. On one occasion material, which had packed around the right separator rotor intake caught on fire. The exterior of the combine had many ledges, which collected large amounts of crop material (FIGURE 13). These ledges were hard to clean. It is recommended that the manufacturer consider modifications to prevent chaff and debris from collecting in and on the combine.

FIGURE 13. Chaff and Straw Build-up on the Combine.

Lubrication: Ease of lubrication was fair. Lubrication was time consuming. Greasing the separator rotor universal joints was very difficult.

Fifty-two fittings required greasing. Fifteen required greasing every 10 hours, twenty-one every 50 hours and an additional sixteen every 100 hours. Oil levels required regular checking.

Maintenance: Ease of performing routine maintenance on the Versatile Trans-Axial 2000 was good.

Large hinged doors and panels opened to provide easy access to machine components and drives. Metric tools were required since metric hardware was used throughout the entire combine.

POWER REQUIREMENTS

The manufacturer recommended a minimum tractor size of 130 PTO hp (97 kW). It is unlikely that this would be adequate for many conditions.

Input power measured in Columbus wheat was 125 hp (93.3 kW) at capacity (FIGURE 14). Additional tractor power was required to pull the combine with a full grain tank especially in hills or soft ground. Also, extra power may be required in tough crop conditions or when unloading on-the-go. Therefore, PAMI suggests that a tractor with at least 175 hp (130.6 kW) is needed to adequately power the Versatile Trans-Axial 2000 in typical harvest conditions.

During the tests, the combine was powered with a 240 hp (182 kW) four-wheel drive tractor. This tractor had adequate power for all conditions.

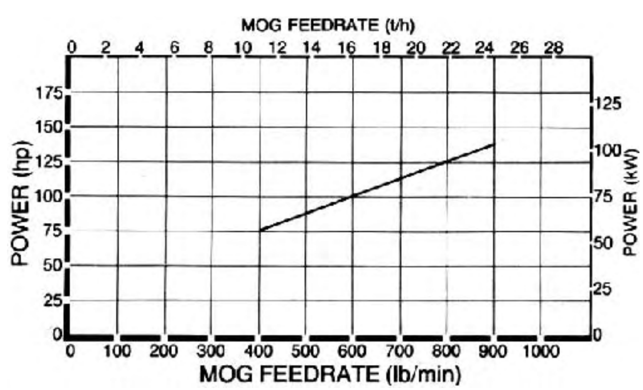

FIGURE 14. Power Requirement in Columbus Wheat.

OPERATOR SAFETY

The operator's manual emphasized operator safety.

Most drives were well shielded. A dual header lock was provided and should be used when working around the combine. Care must be taken when swinging the unloading auger in or out. It swings very near the top of the grain tank access ladder and could easily knock a person off the ladder or pin them against the combine.

Caution must be exercised when working beneath the large side panel doors, which could blow shut in strong winds.

The combine was equipped with a slow moving sign and warning lights to aid in safe road transport. However, care had to betaken when transporting as rear visibility was restricted.

A fire extinguisher (Class ABC) should be carried on the combine at all times.

OPERATOR'S MANUAL

The operator's manual was good. It contained useful information on safety, lubrication, maintenance, operation, and specifications. There were several incorrect references in the lubrication section and incorrect information in the specification sections. It is recommended that the manufacturer consider making changes to the operator's manual to correct these errors.

MECHANICAL HISTORY

The intent of the test was evaluation of functional performance. Extended durability testing was not conducted. However, TABLE 6 outlines the mechanical history of the Versatile Trans-Axial 2000 combine for the 90 hours of field operation during which about 753 ac (304 ha) of crop were harvested. Some of the more serious failures are also discussed.

TABLE 6. Mechanical History

Item	Operating Hours	Field Area ac	(ha)
Electrical:			
-Components in the monitor control box came loose and were repaired at		Start of Test	
-Switches for adjusting fan speed and cylinder speed worked opposite to the labelling and were rewired at		Start of Test	
-The brush assembly for the unloading auger clutch was damaged and replaced at	60	460	(186)
-The header engaging switch on the monitor sometimes did not engage		Throughout the Test	
Drives:			
-The cylinder variable speed drive belt broke and was replaced at	16, 48	103, 371	(42), (150)
-The PTO driven gearbox case cracked and was replaced under warranty at	28	194	(79)
-The table auger speed sensor failed and was repaired at	32	230	(93)
-The rotor drive belts broke and were replaced at	60	460	(186)
-The unloading auger magnetic clutch failed and was replaced at	65	513	(208)
Miscellaneous:			
-The feeder chain adjustment came loose and was retightened at	28, 62	194, 471	(79), (191)
-The separator grates bent		Sometime During the Test	
-The railings elevator drive sheave wore On the bottom of the grain tank		Throughout the Test	
-Several cylinder rasp bars bent due to plugging		Sometime During the Test	
-The rotor drive belt guide was damaged and repaired at	60	460	(185}
-Several bolt heads stripped when being removed		Throughout the Test	

Cylinder Variable Speed Belt: On two occasions the variable speed belt broke when the cylinder plugged. On both occasions plugging was due to the large opening at the front of the concave, which allowed a wad of material to be taken in. On one occasion the slow cylinder speed used resulted in a high torque load.

PTO Gearbox: The case of the angle gearbox, which is driven by the PTO, cracked during operation and began leaking oil. The case was replaced under warranty. It is recommended that the manufacturer consider modifications to prevent case failure of the PTO driven gearbox.

Cylinder Hub: The rasp bar support hub bent when a large wad was fed into the cylinder (FIGURE 15). It is recommended that the manufacturer consider strengthening the rasp bar support hubs to prevent them from bending.

Rotor Drive Belts: The rotor drive belts broke when the combine was unloading while stopped. No cause was determined although it is possible the belts wedged in the belt guide. The belt guide was broken off and the unloading auger clutch brush assembly was damaged. The guide was repaired and the brush assembly replaced. No further problems occurred.

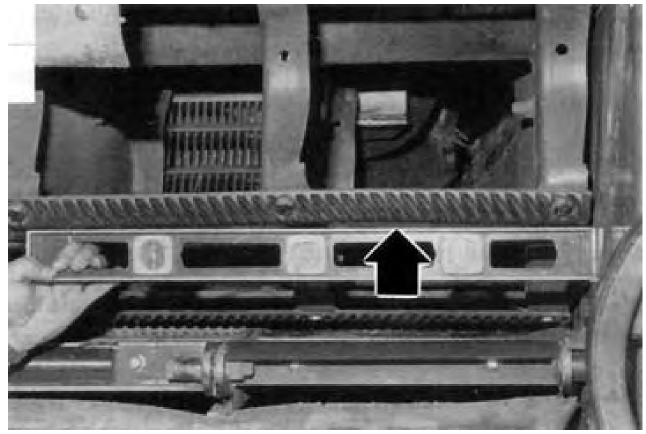

FIGURE 15. Bent Rasp Bar and Support Hub.

Unloading Auger Clutch: The unloading auger clutch failed to unload a tank of dry canola. The clutch faces were worn and the magnetic clutch slipped. No obstructions were found in the unloading auger. The magnetic clutch was replaced and no further problems occurred.

The magnetic clutch failure may have been caused when the rotor belts broke. The belts jammed the auger drive causing the clutch to slip. This may have overheated the magnetic clutch causing it to fail a short time later.

Monitor Control Box: One of the printed circuit boards and ribbon connectors inside the control box came loose during transport. They were secured with an adhesive and no further problems occurred. It is recommended that the manufacturer consider mounting the components in the control box more securely.

The switches for cylinder speed and fan speed worked opposite to their labelling. The problem was corrected by reversing the wires on the linear actuators. It is recommended that the manufacturer consider wiring the cylinder speed and fan speed controls correctly.

Tailings Elevator Drive Sheave: When the grain tank was full the floor sagged and the bottom of the hopper rubbed against the tailings elevator drive sheave (FIGURE 16). Continued use would have worn a hole into the grain tank. It is recommended that the manufacturer consider modifications to prevent the grain tank from contacting the tailings auger drive sheave.

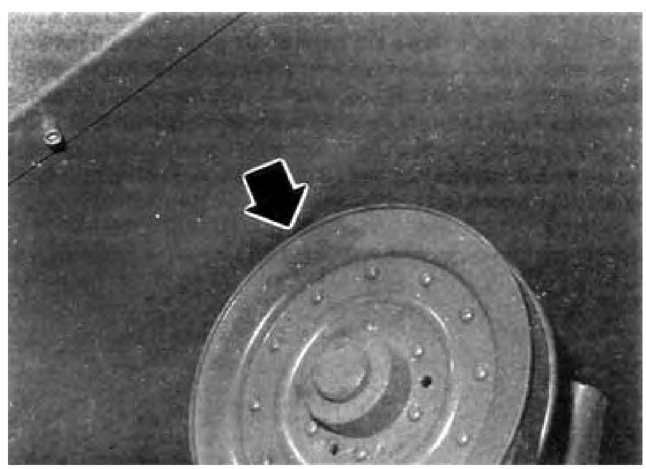

FIGURE 16. Grain Hopper Damage.

Bolt Head Stripping: The Versatile Trans-Axial 2000 combine was assembled with metric hardware. Many of the bolt heads were not durable enough and were stripped when attempting to loosen the bolts. It is recommended that the manufacturer consider using bolts with more durable heads.

APPENDIX I
SPECIFICATIONS

MAKE:	Versatile
MODEL:	Trans-Axial 2000
SERIAL NUMBER:	Body - 255588
MANUFACTURER:	Versatile Farm Equipment Winnipeg, Manitoba
WINDROW PICKUP:	
-- make	Melroe 388
-- type	rubber draper and transfer belts
-- pickup width	10 ft (3.0 m)
-- number of belts	7
-- type of teeth	steel
-- number of rollers	4
-- height control	castor gauge wheels
-- speed control	electric over hydraulic
-- speed range	0 to 435 ft/min (0 to 2.2 m/s)
HEADER:	
-- type	centre feed
-- width - table	12 ft (3.6 m)
- feeder house	41.5 in (1055 mm)
-- auger diameter	24 in (610 mm)
-- feed conveyor	3 chains with under shot slatted conveyor
-- conveyor speed	9.2 ft/s (2.8 m/s)
-- number of lift cylinders	2
STONE PROTECTION:	
-- type	sump type in front of cylinder
-- ejection	manually opened and closed
CYLINDER:	
-- type	alternating rasp bars
-- number of bars	8
-- diameter	32 in (814 mm)
-- width	78.75 in (2000 mm)
-- drive	variable speed belt to triple band V-belt
-- speeds	410 to 1055 rpm
CONCAVE:	
-- number	1, main concave and 2, side concave extensions
-- type	bar and wire
-- number of parallel bars	11
-- configuration	10 intervals with 0.25 in (6 mm) diameter wires
-- area	
- concave total	1426 in² (0.92 m²)
- concave open	662 in² (0.43 m²)
-- open area	47%
-- wrap	99 degrees
-- grain delivery to shoe	ribbed grain pan
-- options	filler plates
SEPARATING ROTORS:	
-- number	2
-- type	hexagonal tubes with intake flighting and staggered separating blades
-- diameter	21 in (530 mm)
-- length	92 in (2340 mm)
-- speed	1000 rpm
SEPARATING GRATES:	
-- number	4 to each rotor
-- type	pressed steel, square holes
-- wrap	180 degrees
-- area	
- grate total	2045 in² (1.32 m²)
- grate open	821 in² (0.53 m²)
-- open area	40%
-- grain delivery to shoe	2 auger conveyors under each rotor
SHOE:	
-- type	opposed action
-- speed	270 rpm
-- chaffer sieve and tailings sieve	adjustable lip 4510 in² (2.91 m²) with 2.5 in (63.5 mm) throw
-- tailings sieve	adjustable lip 900 in² (0.58 m²)
-- clean grain sieve	adjustable lip 3750 in² (2.42 m²) with 2.5 in (63.5 mm) throw
CLEANING FAN:	
-- type	6 blade undershot, dual fans
-- diameter	23 in (585 mm)
-- width	33.5 in (850 mm) each
-- drive	electrically controlled v/s belt
-- speed range	450 to 1100 rpm
ELEVATORS:	
-- type	roller chain with rubber flights
-- clean grain (top drive)	8 in x 10 in (200 x 250 mm)
-- tailings (top drive)	5 in x 10 in (125 x 250 mm)
GRAIN TANK:	
-- capacity	214 bu (7.78 m³)
-- unloading time	194 s
-- unloading auger diameter	13.75 in (350 mm)
-- unloading auger length	185 in (4700 mm)

STRAW SPREADER:	
-- type	steel hub with rubber bats
-- speed	230 rpm
CLUTCHES:	
-- header	electro-magnetic
-- separator	PTO
-- unloading auger	electro-magnetic
NUMBER OF CHAIN DRIVES:	8
NUMBER OF BELT DRIVES:	14
NUMBER OF GEARBOXES:	2
LUBRICATION POINTS:	
-- 10 h	15
-- 50 h	21
-- 100 h	16
TIRES:	23.1 x 26, R3, 10-ply diamond tread
OVERALL DIMENSIONS:	
-- wheel tread	12.2 ft (3.7 m)
-- transport height	11.9 ft (3.6 m)
-- length	31.9 ft (9.7 m)
-- width	14.3 ft (4.3 m)
-- field height	11.9 ft (3.6 m)
-- length	23.0 ft (7.0 m)
-- width	17.2 ft (5.2 m)
-- unloader discharge height	12.0 ft (3.7 m)
-- unloader reach (in line with hitch pin)	5.8 ft (1.8 m)
-- unloader clearance	11.7 ft (3.6 m)
WEIGHT (GRAIN TANK EMPTY):	
-- both wheels	16775 lb (7609 kg)
-- hitch point	<u>1618 lb (734 kg)</u>
TOTAL	18393 lb (8343 kg)

APPENDIX II

PAMI REFERENCE COMBINE CAPACITY RESULTS

TABLE 7 and FIGURES 17 and 18 present the capacity results for the PAMI reference combines in barley and wheat crops harvested in 1984 to 1986.

FIGURE 17 shows capacity differences in barley crops for 1984 and 1986. The 1986 Harrington barley crop shown in TABLE 7 had lower than average straw yield and slightly lower than average grain yield. It also had slightly below average straw and grain moisture,

FIGURE 18 shows capacity differences in wheat crops for the two years. In 1986 the Katepwa wheat crop had higher than average straw yield, and average grain yield. It also had average grain moisture and slightly below average straw moisture content. Results show that the reference combine is important in determining the effect of crop variables and in comparing capacity results of combines evaluated in different years.

TABLE 7. Capacity of the PAMI Reference Combines at a Total Grain Loss of 3% Yield

		Crop Conditions									Capacity Results							
				Width of Cut		Crop Yield		Moisture Content		MOG/G	MOG Feedrate		Grain Feedrate		Grain Cracks	Dockage	Foreign Material	Loss
		Crop	Variety	ft	m	bu/ac	t/ha	Straw %	Grain %	Ratio	lb/min	t/h	bu/h	t/h	%	%	%	Curve
REF II	1986	Barley	Harrington[1]	56	17.0	62	3.3	10.5	10.8	0.64	424	11.6	828	18.1	0.4	0.3	0.2	17
		Wheat	Columbus[1]	56	17.0	51	3.4	8.8	16.7	1.14	647	17.7	568	15.5	1.5	4.6	3.5	
		Wheat	Katepwa	29	8.9	49	3.3	6.5	14.0	1.32	644	17.6	488	13.3	1.8	1.7	1.0	18
	1984	Barley	Bonanza[1]	42	12.8	52	2.8	15.0	11.2	0.70	363	9.9	648	14.1	0.5	1.0		17
		Barley	Bonanza	24	7.3	77	4.1	11.3	11.6	0.66	352	9.6	687	14.6	0.5	1.0		
		Wheat	Neepawa[1]	44	13.4	36	2.4	6.3	10.9	1.32	539	14.7	408	11.1	1.1	5.5		18
		Wheat	Neepawa	22	12.8	44	3.0	8.7	10.2	1.18	601	16.4	509	13.9	4.5	7.0		
REF I	1986	Barley	Harrington	28	8.5	59	3.7	10.5	9.2	0.56	294	8.0	656	14.3	0.8	0.5	0.2	
		Wheat	Columbus[1]	42	12.8	32	2.2	11.8	14.7	1.09	438	12.0	402	11.0	1.2	4.9	3.0	
		Wheat	Katepwa	29	8.9	50	3.4	7.5	14.1	1.33	420	11.5	316	8.6	1.3	1.5	0.7	
	1985	Barley	Argyle[1]	60	18.0	75	4.0	25.5	11.4	0.94	293	8.0	390	8.5	2.0	1.0	0.4	
		Barley	Bonanza[1]	55	16.8	83	4.5	21.0	15.0	0.76	285	7.7	469	10.2	1.0	1.7	1.2	
		Wheat	Neepawa[1]	42	12.8	42	2.8	23.7	18.0	1.43	391	10.7	273	7.5	4.9	2.3	0.2	
		Wheat	Katepwa[1]	41	12.5	82	4.2	24.8	18.5	0.95	435	11.9	458	12.5	2.5	1.3	0.2	
	1984	Barley	Bonanza[1]	42	12.8	68	3.7	18.5	12.9	0.74	275	7.5	464	10.1				
		Barley	Bonanza	24	7.3	85	4.8	12.0	12.1	0.62	213	5.8	429	9.4				
		Wheat	Neepawa[1]	44	13.4	42	2.8	6.7	11.8	1.47	308	8.4	209	5.7				
		Wheat	Neepawa[1]	42	12.8	41	2.8	8.5	10.3	1.17	356	9.7	304	8.3				
		Wheat	Neepawa[1]	42	12.8	23	1.8	7.2	12.5	0.99	345	9.4	348	9.5				

[1]Side by side double windrows

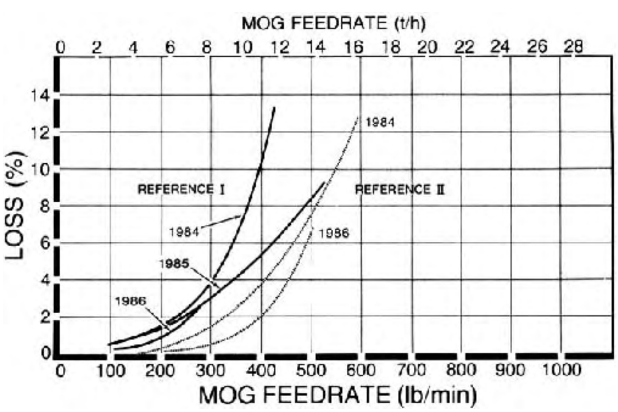

FIGURE 17. Total Grain Loss for the PAMI Reference Combines in Barley.

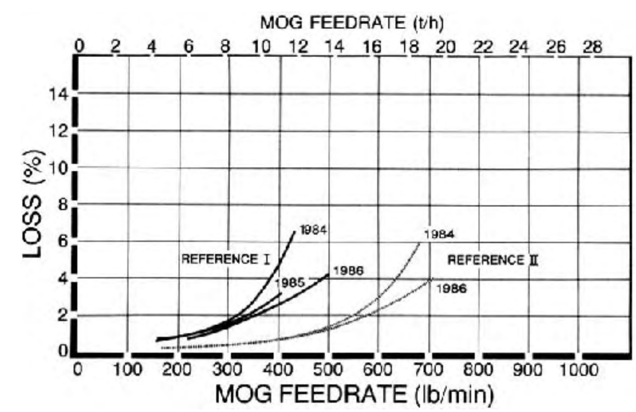

FIGURE 18. Total Grain Loss for the PAMI Reference Combines in Wheat.

APPENDIX III
REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations for the capacity results shown in FIGURES 2 to 4 are presented in TABLE 8. In the regressions, U = unthreshed loss in percent of yield, S = shoe loss in percent of yield, R = rotor loss in percent of yield, F = the MOG feedrate in lb/min, while $\ln$ is the natural logarithm. Sample size refers to the number of loss collections. Limits of the regressions may be obtained from FIGURES 2 to 4 while crop conditions are presented in TABLE 3.

TABLE 8. Regression Equations

Crop - Variety	Figure Number	Regression Equations	Simple Correlation Coefficient	Variance Ratio	Sample Size
Barley - Harrington	2	$U = 0.01 + 1.86 \times 10^{-4}F$ $S = 0.10 + 8.99 \times 10^{-9}F^3$ $R = 0.99 + 6.12 \times 10^{-9}F^3$	0.88 0.99 0.99	28.9^2 360^2 517^2	6
Wheat - Columbus	3	U = 0.0.22 $S = 0.01 + 2.77 \times 10^{-9}F^3$ $R = 0.86 + 7.39 \times 10^{-4}F$	 0.97 0.15	 10.8^2 0.9	7
Wheat - Katepwa	4	U = 0.37 $\ln S = -2.98 + 3.58 \times 10^{-3}F^3$ $R = 1.56 - 9.04 \times 10^{-4}F$	 0.90 0.46	 55.80^2 5.0	8

[1]Significant at $P \leq 0.05$
[2]Significant at $P \leq 0.01$

APPENDIX IV
MACHINE RATINGS

The following rating scale is used in PAMI Reports:

excellent	fair
very good	poor
good	unsatisfactory

SUMMARY CHART
VERSATILE TRANS-AXIAL 2000 COMBINE

RETAIL PRICE	$80,400.00 (March, 1987, f.o.b. Humboldt, Sask.)
CAPACITY	
Compared to Reference	
Combine -barley	1.15 x Reference II, 1.70 x Reference I
-wheat	1.20 to 1.40 x Reference II, 1.80 to 2.20 x Reference I
MOG Feedrates	
-- barley -Harrington	485 lb/min (13.2 t/h) at 3% total loss, FIGURE 2
-- wheat -Columbus	790 lb/min (21.6 t/h) at 3% total loss, FIGURE 3
- Katepwa	915 lb/Min (25.0 t/h) at 3% total loss, FIGURE 4
QUALITY OF WORK	
Picking	**Good;** pickup too narrow for some double windrows
Feeding	**Good;** aggressive, excessive shelling
Stone Protection	**Good;** no stone damage occurred
Threshing	**Very Good;** very aggressive
Separating	**Good;** good at high feedrates but poor at low feedrates
Cleaning	**Fair;** limited combine capacity
Grain Handling	**Good;** grain tank would not clean out completely
Straw Spreading	**Fair;** up to 20 ft (6.1 m), uneven spread
EASE OF OPERATION AND ADJUSTMENT	
Hitching Comfort	Depends on tractor
Instruments	**Good;** easy to observe day or night
Controls	**Good;** easy to operate
Lighting	**Poor;** grain tank and unloading lights inadequate
Handling	**Good;** easily put into transport
Adjustment	**Good;** concave inconvenient to adjust
Setting	**Fair;** difficult to separate rotor and shoe effluent
Unplugging	**Fair;** cylinder could not be reversed
Cleaning	**Poor;** chaff and debris collected on many areas
Lubrication	**Fair;** separator rotor universal joints very difficult to grease
Maintenance	**Good;** removable doors and shields provided easy access
POWER REQUIREMENTS	PAMI recommends a minimum 175 PTO hp (130 kW) tractor
OPERATOR SAFETY	All moving parts well shielded
OPERATOR'S MANUAL	**Good;** several incorrect references
MECHANICAL HISTORY	A few mechanical problems occurred

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